Colorado Medium- and Heavy-Duty (M/HD) Vehicle Study

Colorado Energy Office

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Acknowledgements

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This report is available at www.mjbradley.com.

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List of Key Acronyms

ACT – Advanced Clean Trucks Rule
AID – Accelerated Innovation Deployment
ARRA – American Recovery and Reinvestment Act of 2009
ASE – Automotive Service Excellence
BEV – Battery electric vehicle
CARB – California Air Resources Board
CARS – Consumer Assistance to Recycle and Save
CDOT – Colorado Department of Transportation
CDPHE – Colorado Department of Public Health & Environment
CEC – California Energy Commission
CEO – Colorado Energy Office
CH_4 – Methane
CI – Carbon intensity
CIG – Capital investment grants
CMAQ – Congestion Mitigation Air Quality
CNG – Compressed natural gas
CO – Colorado
CO_2 – Carbon dioxide
CO_2e – CO_2 equivalent
DCFC – Direct current fast charging
DERA – Diesel Emissions Reduction Act
DOE – Department of Energy
DOT – Department of Transportation
DRCOG – Denver Regional Council of Governments
EJ – Environmental justice
EPA – Environmental Protection Agency
EIA – Energy Information Administration
ESG – Environmental, social and governance
EV – Electric vehicle
EVITP – Electric Vehicle Infrastructure Training Program
EVSE – Electric vehicle supply equipment
FCEV – Fuel cell electric vehicle
FHWA – Federal Highway Administration
FLAP – Federal Lands Access Program
FTA – Federal Transit Administration
GHG – Greenhouse gas
GREET – Argonne National Laboratory's Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies Mode Model
GVWR – Gross vehicle weight rating
GWP – Global warming potential
HC – Hydrocarbon
HDV – Heavy-duty vehicle
HOT – High occupancy toll
HOV – High occupancy vehicle
HVIP – Heavy-Duty Voucher Incentive Program
ICAM – Innovative Coordinated Access for Mobility
ICE – Internal combustion engine
INFRA – Infrastructure for Rebuilding America
IOU – Investor owned utility
kW – Kilowatt

kWh – Kilowatt-hour
LCFS – Low Carbon Fuel Standard
LD – Light-duty vehicle
LEZ – Low emission zone
LMI – Low-to-moderate income
MBUF – Mileage based user fees
MDV – Medium-duty vehicle
M/HD – Medium- and heavy-duty
MOVES – EPA's Motor Vehicle Emission Simulator
MPG – Miles per gallon
MPO – Metropolitan planning organization
MT – Metric ton
MW – Megawatt
MWh – Megawatt-hour
MY – Model year
N_2O – Nitrous oxide
NFRMPO – North Front Range Metropolitan Planning Organization
NHTSA – National Highway Transportation Safety Agency
NJ ZIP – New Jersey Zero Emissions Incentive Program
NOx – Nitrogen oxide
NSFLTP – Nationally Significant Federal Lands and Tribal Projects
OEM – Original equipment manufacturer
OSHA – Occupational Safety and Health Administration
PAYS – Pay-As-You-Save
PHEV – Plug-in hybrid electric vehicle
PM – Particulate matter
$PM_{2.5}$ – Particulate matter <2.5 microns
PM_{10} – Particulate matter <10 microns
PUC – Public Utility Commission
RAISE – Rebuilding American Infrastructure with Sustainability and Equity
RAQC – Colorado’s Regional Air Quality Council
RNG – Renewable natural gas
RTD – Regional Transportation District
SAE – Society of Automotive Engineers
SIP – State implementation plan
TABOR – Taxpayer’s Bill of Rights
TCI-P – Transportation and Climate Initiative Program
TEP – Transportation Electrification Program
T-ESCO – Transport energy service company
TNC – Transportation network company
TOU – Time of use
V2G – Vehicle to grid
VMT – Vehicle miles traveled
VW – Volkswagen
WTP – Well-to-pump
ZEV – Zero emission vehicle
ZEZ – Zero emission zone

Executive Summary

The state of Colorado has implemented a number of key policies that have made the state a leader in addressing climate change. In order to reduce pollution and achieve the state's greenhouse gas emissions (GHG) reduction goals, Colorado must significantly reduce emissions from the transportation sector, which currently accounts for 25 percent of the state's GHG emissions. The Polis Administration has already recognized zero-emission vehicles (ZEVs)[i] as being a key part of the state's climate and energy agenda and has committed the state to moving towards a zero-emitting transportation future. A key component of this larger strategy is developing a plan for the medium- and heavy-duty (M/HD) vehicle sector.[ii]

This M/HD ZEV Study finds that if the state of Colorado pursues strategies that support an accelerated transition to M/HD ZEV— a component of the state's larger goal of achieving a 100 percent ZEV transportation sector by 2050—it could reduce the state's GHGs by 3.3 to 4.4 million metric tons, nitrogen oxide (NOx) by 7,000 to 12,100 metric tons, and particulate matter (PM) emissions by 111 to 140 metric tons annually in 2050 depending on the level of ZEV adoption. Not only will this have a meaningful impact on the state's contribution to climate change but it will also improve air quality.

Achieving this ambitious goal will require leveraging a wide range of policy levers and support from a diverse set of stakeholders, including both public and private entities. State entities have a key role to play in reducing the risk and uncertainty in the M/HD ZEV market—for fleet operators as well as other key stakeholders throughout the vehicle value chain. By supporting a long-term planning process that includes the thoughts and insights of original equipment manufacturers (OEMs), large fleet operators, coalitions of small fleet operators (e.g., trucking associations), logistics hubs, utilities, private infrastructure providers, government agencies, and community advocates, state leadership can begin to develop a zero-emission pathway that considers the differing needs of a diverse coalition of stakeholders.

This report summarizes the results of several work streams undertaken to assist the Colorado Energy Office (CEO), Colorado Department of Transportation (CDOT), and Colorado Department of Public Health and Environment (CDPHE) in developing an effective strategy toward a zero emission M/HD vehicle sector by: (1) developing a national and state-level landscape assessment of the M/HD vehicle sector, (2) conducting a Colorado-specific fleet fuel and emissions analysis, (3) collecting perspectives and ideas to further facilitate the transition from stakeholders, (4) identifying and evaluating available policy levers and key implementation considerations that the state should evaluate when developing a detailed M/HD ZEV strategy, and (5) conducting a cost-benefit analysis for highlighted strategic policies to determine the potential benefits to society and impacts on electric utility rates that the state of Colorado could experience.

A few notable takeaways from each part of the analysis are highlighted below and are discussed fully in other sections of the report.

Medium- and Heavy-Duty Market Landscape Review

The national market for M/HD ZEVs is anticipated to grow dramatically in the coming years with vehicle costs declining and more models being introduced. Key considerations like workforce development and supply chain concerns need to be evaluated both at the national and state level to ensure that the M/HD

[i] CEO defines a zero-emission vehicle as a battery electric motor vehicle or a hydrogen fuel cell motor vehicle.
[ii] Medium- and Heavy-Duty vehicles are defined as those with gross vehicle weight rating (GVWR) of 8,501 lb and greater.

vehicle market is prepared for the transition to ZEVs. Understanding the existing M/HD vehicle populations and their usage patterns is a critical first step to understanding what types of market interventions (incentives, regulations, advisory services, etc.) will be needed for the state to support the turnover of the M/HD fleet to ZEVs. Key highlights from the national and state M/HD market landscape review are outlined below.

National Market Trends and Technology Considerations

Nationally, the current market for M/HD ZEVs is still relatively nascent but poised for growth. While recent announcements show that manufacturers across the industry are starting to significantly invest in expanding access to ZEV options, they currently have limited production capacity, producing small batches of a few hundred vehicles annually. To date, the electric transit and school bus markets are the most mature.

With the right combination of regulations and incentives, electric buses could follow – or exceed – their current growth trajectory. While roughly 13 percent of the country’s transit agencies currently have electric buses in their fleet or have them on order, one third of transit agencies in the U.S. have committed to convert to zero-emission vehicles by 2045.[1] Today, every North American manufacturer of diesel buses also sells electric buses and those offerings will continue to grow.

The electric school bus market is progressing rapidly, with electric models available from several major manufacturers. Although penetration is low to date, this will be an important sector to electrify as school buses outnumber transit buses roughly five to one.[2]

Vehicle usage patterns will impact how readily a M/HD vehicle operator/owner is able to transition to ZEVs. Spanning the M/HD sector is a diverse group of vehicles ranging from city delivery vehicles and conventional vans to cement and long-haul trucks. Within these different vehicle classes, exists a variety of vehicle types which have a wide range of uses and varying operating characteristics. These differences range from having a minimal impact on the functionality of a vehicle (i.e., a truck that is used for general operations will have different vehicle requirements when compared to a similarly sized truck that is used to plow snow during the winter) to having a significant impact on a fleet’s ability to transition to ZEVs (i.e., a long-haul truck and a regionally operated delivery van will face significantly different barriers to transitioning to ZEVs based upon their vehicle usage patterns and access to fueling infrastructure).

Nationally, the market for M/HD ZEVs will need increased technological innovation, supply chain and workforce development. Today, almost all available M/HD EVs have limited range, typically under 150 miles. In the coming years, however, manufacturers like Tesla and Nikola anticipate trucks that can travel hundreds of miles on a single charge. In order to reach these goals, increased research, development, and demonstration projects will be needed within both the public and private sector. Additionally, and critically important to M/HD ZEV deployment, is the development of a robust supply chain to ensure both component availability and greater lifecycle emissions reductions. Within the EV market, battery mining and manufacturing contribute the most to the lifecycle emissions of an electric vehicle. Vehicles and batteries manufactured in the U.S. — especially if manufacturing is taking place in U.S. states with rapidly decarbonizing electric grids — will produce greater lifecycle emissions reductions, particularly compared to manufacturing occurring in Asia. Looking beyond the initial manufacturing of the ZEVs, to the maintenance and operation of the vehicles, federal and state governments will need to continue to develop and support updated vehicle technician and electrician trainings that will build the vehicle workforce of the future.

Colorado Landscape Considerations

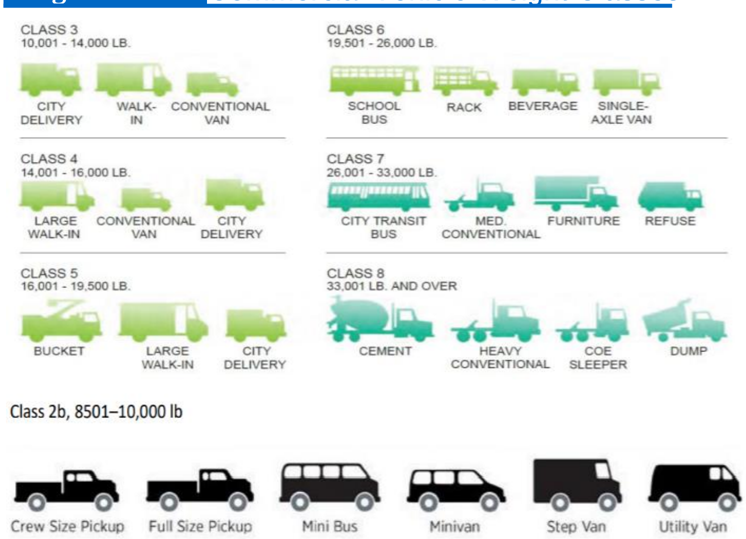
Colorado's state and local governments could make a significant contribution to the state's M/HD ZEV goals by leading by example in procuring ZEVs. A review of state registration data yields information about the types of fleets and size throughout Colorado.[iii] State, county, and city governments, including transit authorities and school districts, own about half of the vehicles in the 100 largest fleets in Colorado. Utilities, including electric companies, oil and gas companies, and water and waste authorities, make up an additional 14 percent of vehicles. Truck rentals, and delivery services vehicles constitute approximately 11 percent each. Construction vehicles constitute approximately 12 percent. Combined, these segments represent a significant procurement opportunity within the state.

M/HD vehicles often remain on the road longer than light-duty vehicles (LDV), suggesting the importance of supporting significant uptake of ZEV purchases by 2030 to achieve the state's long-term transportation emission reduction goals. This study's analysis implies an average M/HD vehicle life of 33 years, and an "effective" life (i.e. when 90 percent or more of total mileage is driven) of less than 20 years. Currently, nearly half of the M/HD fleet within Colorado is older than 14 years with approximately 16 percent of vehicles built before 2000.

Class 3 vehicles, as the second largest population of trucks registered in Colorado, represent a clear opportunity for ZEV deployment. This is also one of the most developed M/HD vehicle markets to date as a number of vehicle manufacturers have announced zero-emission Class 3 models in recent years. A clear signal has been demonstrated in the market best summarized by comparing growth patterns of Class 3 trucks to all M/HD trucks – since 1990, Class 3 sales have grown by a factor of 15.6 compared to only 2.9 for all M/HD trucks.[3] Because of their fleet and usage patterns, Class 3 trucks have the potential to improve local air quality within densely populated areas thereby improving human health.

Class 2b trucks, which represent over half of Colorado's M/HD vehicles, are unique and will require different strategies to transition to ZEVs.[iv] Based on a review of state registration data, it can be surmised that a very large portion of the Class 2b vehicles are either personal vehicles or are owned by very small (less than 5 vehicles) commercial fleets within the state. Transitioning these to ZEV will require focus on commercial and personal truck owners and, for example, if incentives are used, providing access for both groups of owners.

Figure ES-1 Commercial Vehicle Weight Classes



Source: U.S. Department of Energy

[iii] Data source: registration data purchased by CDPHE from IHS Markit as well as state-maintained fleet records.
[iv] Ibid.

Policy Considerations

To be successful, state policies related to zero-emissions M/HD vehicles must focus on increasing coordination and communication among government and private sector stakeholders, lowering ZEV costs, and providing market certainty for both fleet owners and infrastructure developers.

Increasing Coordination and Communication

Increase coordination across M/HD vehicle stakeholders: State entities should work with utilities, fleet operators, and OEMs to ensure coordinated infrastructure build-out. Organizations such as the Colorado Freight Advisory Council and Colorado Electric Vehicle Coalition will continue to provide invaluable advisory expertise and feedback. State leadership can play a key role in developing a space where stakeholders can gather to share perspectives and knowledge on what will be required for different fleets and locations to transition to ZEVs.

Develop coordinated policy: Colorado should continue coordinating efforts with key stakeholders (e.g., OEMs, large fleet operators, coalitions of small fleet operators {or trucking associations}, logistics hubs, utilities, private infrastructure providers, government agencies, and community advocates) around ZEVs in order to set predictable goals and targets for these key stakeholders to plan toward. State leaders will need detailed and forward-looking electrification planning processes that consider the rollout of various vehicle types and where they are likely to charge or be refueled.

Harness and streamline existing relationships to increase ZEV workforce training opportunities within the state: Many community colleges within the state have successful, long-standing relationships with OEMs. However, they could benefit from an entity that is able to convene multi-stakeholder workgroups or task forces to organize a coordinated approach for development of ZEV training programs across the state. The state could serve as an organizing body for convening stakeholders in developing a ZEV curriculum in a coordinated rather than siloed approach.

Leverage expertise of key stakeholders: Providing a space for utilities, fleet operators, state entities, and vehicle manufacturers to share their distinct and critical expertise will be essential to ensuring that infrastructure buildout is coordinated and factoring in all critical information. Whether investor-, municipally-, or cooperatively-owned, utilities serve a variety of essential roles in the transportation electrification process. When enabled, utilities can support M/HD transportation electrification by 1) educating and helping customers design fleet electrification plans, 2) offering incentives, and 3) by creating rate structures that both benefit customers and the electric grid stability.

Lowering Costs and Speeding up ZEV Deployment

Develop incentives to encourage ZEV procurement: It is important to pair potential regulations with incentives to increase adoption by making ZEV costs more affordable and recognizing the significant cost savings in fuel and maintenance costs over time. With passage of SB21-260 in June 2021, Colorado has established three sustainable enterprise funds (Community Access, Clean Fleet, Clean Transit) that collectively will have more than $730 million to be used to incentivize ZEV infrastructure and vehicle deployments over the next 10 years. In the interim, before the enterprise funds are fully operational, the state will still have to leverage additional federal grant and incentive funding pools while internally developing Colorado-centric policies and funding streams to address the cost differentials between now and 2050, after which internal combustion engine (ICE) cost-parity is predicted for the M/HD market as a whole.

Vehicle turnover rates, procurement cycles, and ownership models are all interrelated and important considerations for ZEV deployment as they indicate —all else being equal— how quickly the average vehicle will be replaced: In many cases, the average vehicle's life is more than 30 years, meaning that for states prioritizing increased M/HD ZEV deployment in the near term, market interventions such as financial incentives, ZEV procurement regulations, and infrastructure development will need to be implemented to accelerate the ZEV deployment process.

Evaluate innovative solutions that lower barriers for M/HD vehicle fleet operators: To drive broad fleet transitions to ZEVs at scale, the state will need to look beyond vehicle total cost of ownership and address the wider set of challenges that fleets face in transitioning to M/HD ZEVs, such as existing M/HD vehicle business model constraints and other soft costs (e.g., administrative fees, siting constraints, among other costs or processes).

Providing Market Certainty

Evaluate ways to streamline fueling experiences and costs for fleets operating across the state: State leadership should support ZEV regional and long-haul trucking by working with utilities, OEMs and other key stakeholders to provide technical assistance for regional corridor planning exercises. These exercises will enable key stakeholders to be part of the discussion to ensure ZEV deployment is technology-neutral and considers varying geographic needs.

Develop clear regulatory frameworks and long-term policies: Fleet operators struggle to plan for operations without clear pricing. Uncertainty can be minimized with clear and long-term regulatory and policy certainty. In establishing regulatory frameworks and long-term policies, the state should also consider how best to align with fleet purchasing cycles to ensure coordinated timing of major decisions and planning. The regulatory environment in which a fleet operates or anticipates to operate, can encourage it to become an early adopter of new technologies as a means of complying with regulations.

Establish long term infrastructure build-out plans: Utilities and low- and zero-carbon fuel providers can provide essential insight about fueling infrastructure expansion costs, time requirements, and how to prepare for shifting use-cases. While there are some commonalities across states and regions, real-world facility siting, infrastructure installation and vehicle deployments will require detailed and forward-looking planning processes that consider the specific vehicle vocations and how, when, and where they will be recharged or refueled. Electrifying regional and long-distance trucking cannot be done without the coordination and support of utilities across the state.

Modeling Takeaways and Implications

To evaluate the impact of different policies outlined throughout this report, M.J. Bradley & Associates developed a set of three individual scenarios and modeled them against a baseline that assumes no additional ZEV purchases beyond current market trends. The core scenarios are outlined below. Additionally, the analysis evaluated the effect of electric vehicle charging on the Colorado electric grid and how revenue from vehicle charging could increase the net revenue realized by Colorado's electric utilities.

Baseline — Based on future annual vehicle miles traveled (VMT) and fleet characteristics as projected by U.S. Energy Information Administration (EIA) as part of their Annual Energy Outlook data series[v].

[v] Data was taken from EIA's Annual Energy Outlook 2021 Reference Case tables

ACT – Models the impacts of Colorado adopting California's Advanced Clean Trucks (ACT) Rule. ZEV sales are assumed to be battery electric vehicles and will be the majority of M/HD vehicle purchases in 2035 and beyond.

ACT + NOx – Builds upon ACT scenario by adding California's Heavy-Duty Low NOx Omnibus requirement that 100 percent of M/HD vehicles sold in the state that are not ZEV must meet a low-NOx emission limit after 2024. New vehicles must meet a 75 percent reduction in NOx emissions in 2024, increasing to 90 percent reduction after 2027.

100 X 40 Aspirational – Further builds upon the ACT + NOx scenario by increasing ZEV sales to 90-100 percent by 2040. ZEV and Low NOx vehicles make up 98 percent of vehicles in the state by 2050. It should be noted that this scenario assumes that the state and federal government adopt additional policies to increase ZEV adoption; however, these individual policies have not been contemplated in the context of this analysis. This scenario is highly ambitious, and projects aggressive levels of ZEV sales in the state.

The following section highlights the key takeaways from this modeling exercise:

All scenarios will result in a net societal benefit ranging from $20.2 billion to $26.6 billion (2020$). These net benefits are due to the net financial savings to Colorado M/HD ZEV owners, sizeable GHG monetized savings and air quality benefits along with utility net revenue from increased M/HD electrification.[vi]

Under the ACT scenario, utility net revenue in Colorado is projected to total $23 million in 2030, rising to $95 million in 2050. For the 100 X 40 Aspirational scenario, utility net revenue is projected to total $22 million in 2030 rising to $61 million by 2050.

The scenarios project a total net financial savings of approximately $5.8 billion under the ACT + NOx scenario to $8.3 billion under the 100 X 40 Aspirational scenario (2020$) over the analysis horizon (2021-2050). Although ZEVs initial costs (e.g., vehicle purchase and infrastructure) are greater than conventional gasoline and diesel vehicles, the lower fuel and maintenance costs outweigh purchase costs, resulting in cumulative net financial savings. These savings will be in the form of reduced fuel and maintenance costs to Colorado vehicle owners.

Across scenarios and vehicle types, the average projected incremental purchase costs range from $9,900 to nearly $16,000 in the 2021-2030 timeframe, falling to $2,500 to $3,200 in 2031-2040 and reaching $2,180 and $3,000 per vehicle by 2050. On average, the ACT and ACT + NOx scenarios project incremental purchase costs of nearly $2,180 per M/HD ZEV by 2050, while the 100 X 40 Aspirational scenario projects incremental costs closer to $3,000 per ZEV by 2050. For ZEV infrastructure, costs per ZEV range from $3,926 to $5,191 per vehicle.

ZEVs offer significant fuel cost and maintenance savings. As technology is refined and cost is reduced, ZEVs provide meaningful fuel and maintenance savings on a per-vehicle basis. For fuel savings specifically, each of the modeled scenarios is estimated to result in annual savings ranging from $836 to $1,216 in 2050. Similarly, annual maintenance savings ranging from $807 to $1,111 are projected. In the interim time periods of 2021-2030 and 2031-2040, combined annual fuel and maintenance savings are estimated at approximately $2,100.

[vi] Utility net revenue is considered a societal benefit because, assuming nearly all residents of the state have access to electricity, the opportunity for increased revenue is anticipated to lead to lower electric rates – a benefit to all that purchase electricity.

Introduction

The state of Colorado has implemented a number of key policies that have made the state a leader in addressing climate change. In 2019, the Colorado legislature passed HB19-1261, which established a statewide goal to reduce greenhouse gas (GHG) emissions by at least 26 percent by 2025, 50 percent by 2030, and 90 percent by 2050 compared to a 2005 baseline.[4]

Decarbonization efforts in the transportation sector will be critical in order to ensure that the state meets its emissions reduction goals.[vii] Not only are these emission reductions important to helping the state meet its climate targets but they will also have important implications for improving the state's air quality and the health of Coloradans across the state. The Denver metropolitan area and North Front Range—the state's most populated areas— are not in compliance with federal health-based ozone standards. This is due in part to emissions from the transportation sector and, in particular, from medium- and heavy-duty (M/HD) vehicles whose nitrogen oxide (NOx) emissions represent one of the largest sources of ozone precursors within the state. Transitioning this sector to zero-emission vehicles (ZEVs) would therefore improve the air quality and health of many Coloradans.

Understanding the important role that this sector will play in achieving the state's GHG emission reduction goals, the Polis Administration has made supporting ZEVs a key part of its climate and energy agenda and has committed the state to moving towards a zero-emitting transportation future. To further M/HD progress, Governor Polis joined 14 other Governors and the Mayor of the District of Columbia in signing the M/HD ZEV Memorandum of Understanding, committing the state to work collaboratively to pursue emissions reductions for the M/HD sector. Collectively, these states set a goal to make at least 30 percent of all new medium-and heavy-duty vehicle sales in their jurisdictions zero emission vehicles by no later than 2030.

In an effort to support and implement these targets and goals, the Colorado Energy Office (CEO) released its Colorado Electric Vehicle (EV) Plan in 2020, which established a vision for Colorado's large-scale ZEV transition. A key focus of the EV plan is to develop a strategy for transitioning the state's M/HD vehicles to ZEVs. The plan sets a long-term goal of 100 percent zero-emission M/HD vehicles. To achieve the goal, it commits Colorado to working with industry, electric utilities, and other stakeholders to develop plans for a M/HD ZEV transition, including investigating the adoption of California's Advanced Clean Trucks (ACT) Rule and setting goals for MH/D vehicle adoption that go beyond Volkswagen Settlement funding. Because M/HD vehicles vary so significantly in their size, usage patterns, vocations and existing business models, targeted planning, stakeholder engagement, and fleet modeling will be essential towards determining an optimal path for transitioning Colorado's existing M/HD fleet to ZEVs.

In June 2021, the Colorado legislature passed SB 21-260 "Sustainability of the Transportation System." The bill creates new sources of dedicated funding through state enterprises (government-owned businesses) to support the widespread adoption of ZEVs.[5] As a result of the bill, the state will leverage revenue generated from a host of fees (e.g., for purchases of gasoline and diesel fuel, electric vehicle (EV) registrations, retail deliveries, transportation network companies (TNC) rides, and short-term vehicle rentals)[viii] to fund investments in Colorado's transportation system. New and modified enterprises funded by these fees will

[vii] Similar to national trends, transportation surpassed the electric sector in 2020 as the leading contributor to Colorado's GHG emissions, totaling one quarter of state emissions.

[viii] Revenue collection of the new fees created in the legislation begins in FY 2022-23. Those fees will fund grant programs for ZEV infrastructure and vehicles. Program design and implementation will be informed by 10-year plans, developed by the Enterprise, which are to be completed by June 2022.

help support M/HD fleets from transit agencies to retail delivery fleets on their path of ZEV integration and create an opportunity for the state to scale both LDV and M/HD ZEV markets.

This report highlights different policy levers that key stakeholders and agencies could implement to increase the deployment of M/HD ZEVs, and evaluates what type of emissions reduction could be achieved by deploying a subset of those policies.

Senate Bill 21-260

Signed into Law June 17, 2021

- **New Transportation Fees**: Creates new fees for purchases of gasoline and diesel fuel, EV registrations, retail deliveries, passenger ride services, and short-term vehicle rentals, including:
    - **Road Usage Fee**: Introduces a Road Usage fee for fuel distributors that pay excise tax, paid per gallon of gasoline and diesel.
    - **EV Fee**: Amends the existing $50 EV annual registration fee to be adjusted for inflation annually.
    - **Retail Delivery Fee**: Imposes a new fee on retail drivers, adjusted for inflation annually.
    - **Passenger Ride Fee**: Creates a new fee on passenger rides provided by TNCs, discounted for rides that are pooled or in an EV.
- **New State Enterprises:** Creates new state enterprises funded by various fees, including those described above:
    - **Community Access Enterprise**: To support the widespread and equitable adoption of EVs by investing in transportation infrastructure, providing grants or other financing options to fund the construction of EV charging infrastructure, and incentivizing the acquisition of EVs.
    - **Clean Fleet Enterprise**: To incentivize and support the use of electric and alternative fuel vehicles by business and governmental entities that own or operate motor vehicle fleets.
    - **Clean Transit Enterprise**: To reduce and mitigate the adverse environmental impacts and health impacts of air pollution and GHG emissions by supporting the replacement of existing gasoline and diesel transit vehicles with electric motor vehicles.
    - **Nonattainment Area Air Pollution Mitigation Enterprise**: To mitigate the environmental and health impacts of increased air pollution for motor vehicle emissions in nonattainment areas resulting from the growth in TNC rides and retail deliveries.

House Bill 1266

Signed into Law July 2, 2021

- **Environmental Justice (EJ) Ombudsperson**: Creates position that reports to the Executive Director of Colorado Department of Public Health & Environment (CDPHE) no later than February 2022. Ombudsperson should have been a resident of one or more disproportionately impacted communities or have worked to advance EJ within disproportionately impacted communities.
- **EJ Advisory Board**: Creates CDPHE EJ Advisory Board with twelve members appointed by the Governor no later than November 2021.

Overview

National Medium- and Heavy-Duty Sector

The national M/HD landscape, in terms of current market behaviors and ZEV development, is important to understand before delving into the Colorado-specific fleet. Additionally, it is important to recognize the differences in Federal (and some state) agency definitions of medium- and heavy-duty vehicles. The Federal Highway Administration (FHWA) and Environmental Protection Agency (EPA) have mostly consistent definitions of what a medium- or heavy-duty vehicle is, except in the case of class 2 vehicles. FHWA considers all vehicles from 6,001 to 10,000 lbs. gross vehicle weight rating (GVWR) to be Class 2 and 'light-duty'. EPA further breaks this classification down to Class 2a and 2b and considers Class 2b to be a medium-duty vehicle. Throughout this document, all reference to medium- and heavy-duty vehicles signify Class 2b to Class 8 vehicles.

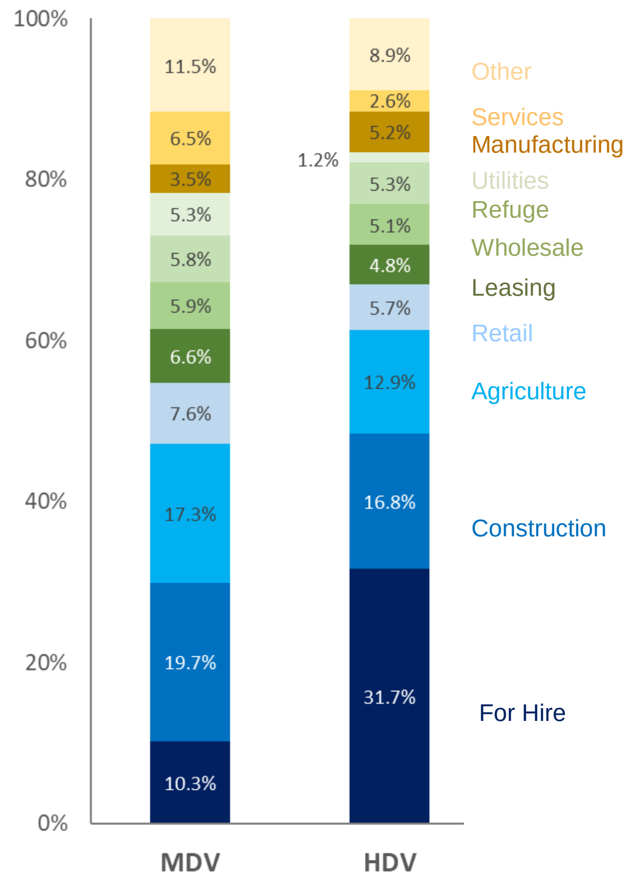
Use and Impact: Overview of the M/HD Vehicle Sector

The M/HD vehicle sector represents a large and diverse set of vehicles that span a number of services and are critical to a wide variety of industries from delivery service providers to the telecom industry. The following section provides an overview of the existing M/HD vehicle sector and offers some key considerations that should be evaluated when transitioning an existing M/HD fleet to a zero-emitting fleet.

Characteristics of the M/HD Vehicle Sector

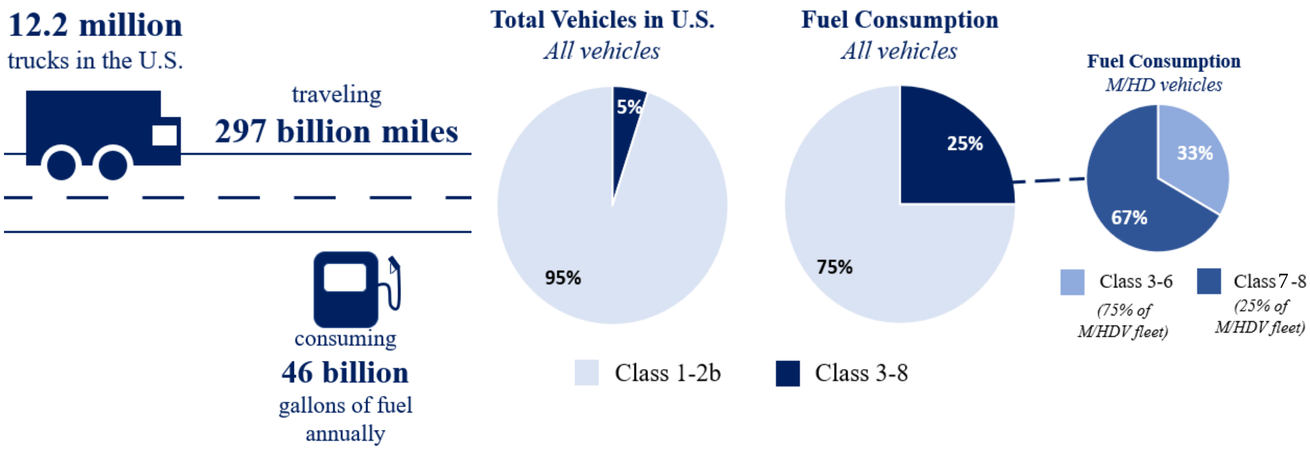
FHWA considers Class 3 (10,001 lbs.) to Class 8 (larger than 33,000 lbs.) as M/HD vehicles within the United States based upon manufacturer-specified GVWR.[6] Spanning this sector is a diverse group of vehicles ranging from city delivery vehicles and conventional vans to cement and long-haul trucks. While a comparatively smaller sector on a per vehicle basis than the LDV sector, the importance of M/HD vehicles to the nation's economy cannot be understated. Almost all goods consumed in the U.S. are shipped by M/HD vehicles for at least part of their trip and, according to the U.S. Department of Transportation (U.S. DOT), trucks carry more than 73 percent of the nation's freight on a value basis.[7]

Figure 1 Percent of U.S. In-Use Trucks



Source: 2002 Vehicle Inventory & Use Survey

Nationally, the M/HD vehicle sector consists of 12.2 million trucks that travel 297 billion miles and consume 46 billion gallons of fuel annually. According to the U.S. Department of Energy (U.S. DOE), Class 3-8 trucks make up less than five percent of the total number of U.S. vehicles but represent a quarter of the annual vehicle fuel use.[8] Of that, combination trucks (tractor-trailers, Class 7 and 8) make up one quarter of the national M/HD fleet but drive approximately 60 percent of annual miles and use two thirds of annual fuel. Nationally, gasoline and diesel account for over 90 percent of M/HD vehicle fuel use.[9] Within these differing vehicle classes exists a variety of vehicle types which have a wide range of uses and varying operating characteristics. These differences in the characterization of the fleet, as will be described in more detail in the coming sections, have a significant impact on its ability to readily adopt ZEVs.



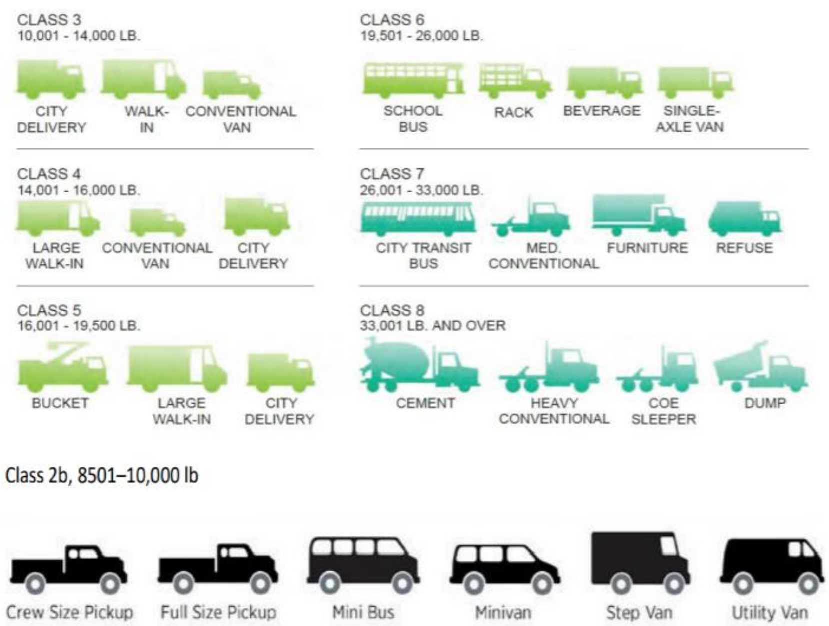
Understanding Vehicle Weight Classifications

FHWA: The vehicle weight classes are defined by the FHWA and are used consistently throughout the industry (see **Figure 2** for vehicle weight classes and categories). Each of these classes, which span from Class One to Class Eight– are based on gross vehicle weight rating (GVWR), the maximum weight of the vehicle, as specified by the manufacturer. FHWA categorizes vehicles as Light-Duty (Class 1–2), Medium-Duty (Class 3–6), and Heavy-Duty (Class 7–8).

EPA: EPA defines vehicle categories, also by GVWR, for the purposes of emissions and fuel economy certification. EPA classifies vehicles as Light Duty (GVWR less than 8,500 lbs.) or Heavy Duty (GVWR greater than 8,501 lbs.). The September 2011 U.S. DOT/EPA rulemaking on Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles uses categories and weights for Heavy-Duty Vehicle Classes 2b through 8, similar to the FHWA weight classes.

CARB: The California Air Resources Board (CARB) established vehicle classes consistent with EPA; however, refers to Classes 2b and 3 as medium-duty vehicles.

Figure 2 Commercial Vehicle Weight Classes

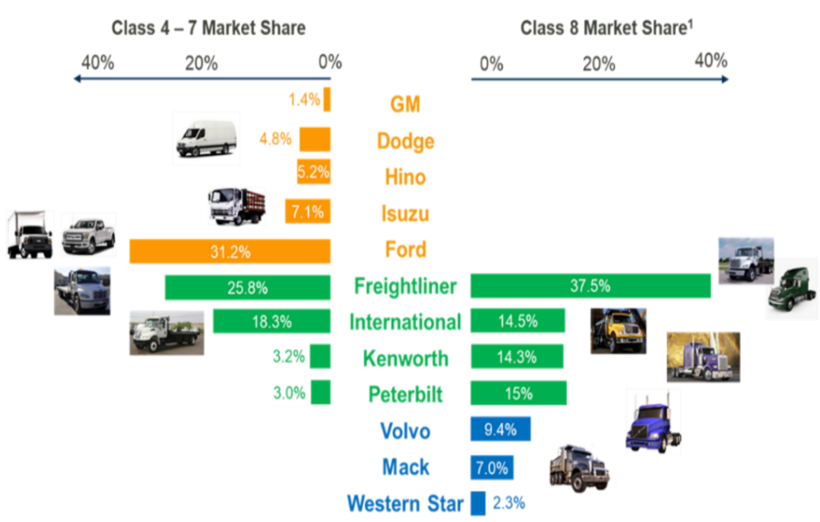


Source: U.S. Department of Energy

Existing Manufacturers

The Class 4-8 subset of U.S. M/HD truck market consists of twelve major original equipment manufacturers (OEMs) (**Figure 3**) which account for over 95 percent of all truck chassis sold. In addition to these OEMs there are numerous secondary or specialty manufacturers. A large percentage of vehicles produced by the OEMs are sold to secondary manufacturers as "cab and chassis", "strip chassis" or "incomplete vehicles".[ix] The secondary manufacturer then adds a vocational body and associated equipment and sells the completed vehicle to fleet users.

Figure 3 M/HD Vehicle Manufacturers by Market Size



Source: American Truck Dealers
**Does not include certain "specialty" vehicles with their own unique sets of manufacturers: Transit Bus, School Bus, Refuse, Yard Tractors*

[ix] A "strip chassis" is a base frame of a truck without a mounted body.

Two of the most influential OEMs with regard to market share are Ford and Freightliner (a division of Daimler Trucks North America); Ford holds nearly one third of the medium-duty market while Daimler's Freightliner follows Ford in the medium-duty market share and also dominates the heavy-duty market with over 37 percent market share of Class 8 trucks.[x]

As OEMs expand M/HD ZEV offerings, announcements from these two OEMs will be particularly influential given their role in the market.

The Class 2b and 3 market covers pickup trucks, sport utility vehicles, full-size vans, and a variety of other truck bodies (e.g., walk-in, chassis cab truck). In the U.S. three companies combined sell the majority of these trucks: Ford, General Motors (e.g. GMC and Chevrolet), and Stellantis (Dodge and Ram).[10]

Existing Fuel Economy Improvement Technology

Over the last 10+ years, trucking fleet owners have looked to OEMs and aftermarket suppliers to develop measures to improve fuel economy, both for new trucks as well as those that can be retrofitted onto existing trucks. The majority of these improvements have focused on long-haul trucking as that segment of the M/HD trucking market uses the most fuel.[11] EPA's SmartWay Transport Partnership Program serves as a clearinghouse for information related to fuel-saving technology and also has a stakeholder component where companies can collaborate and benchmark operations to determine their environmental footprint. On the technology side, SmartWay maintains information on new and retrofit product offerings, such as new freight tractors or trailers or trailer aerodynamic retrofits.

There are a number of methods of achieving fuel economy savings that are somewhat independent of the vehicle vocation, although many are more suited to highway usage, as nationally the over-the-road trucking sector uses significantly more fuel.[12] Additionally, localized trucking is influenced more by local traffic patterns, roadway types, and customer demands. Strategies shown in **Table 1** for achieving fuel reductions can generally be characterized as relating to: (1) driver behavior; (2) vehicle retrofits; and (3) logistic changes. Many fleets may not be able to take advantage of many of these strategies.

Table 1 Fuel Use Reduction Strategies

Driver Behavior	Vehicle/Infrastructure	Logistic Changes

• Slow down
• Reduce discretionary idling
	• Aerodynamic kits – tractor and trailer
	• Low rolling resistance tires
	• Auto-engine start/stop
	• Auxiliary power units / Truck stop electrification
		• Optimize driving routes
		• Assign the right vehicle for the job
		• Off-peak operation
		• Update vehicle specifications
		  ○ Reduce weight
		  ○ Automatic transmission
		  ○ Avoid oversizing

Existing M/HD Vehicle Procurement Cycles

The M/HD vehicle sector has several unique characteristics that will influence how rapidly different fleet operators will be able to transition to a zero emissions fleet. The following sections outline some key considerations that should be evaluated when developing policies aimed at lowering barriers to M/HD zero-emission vehicle procurement.

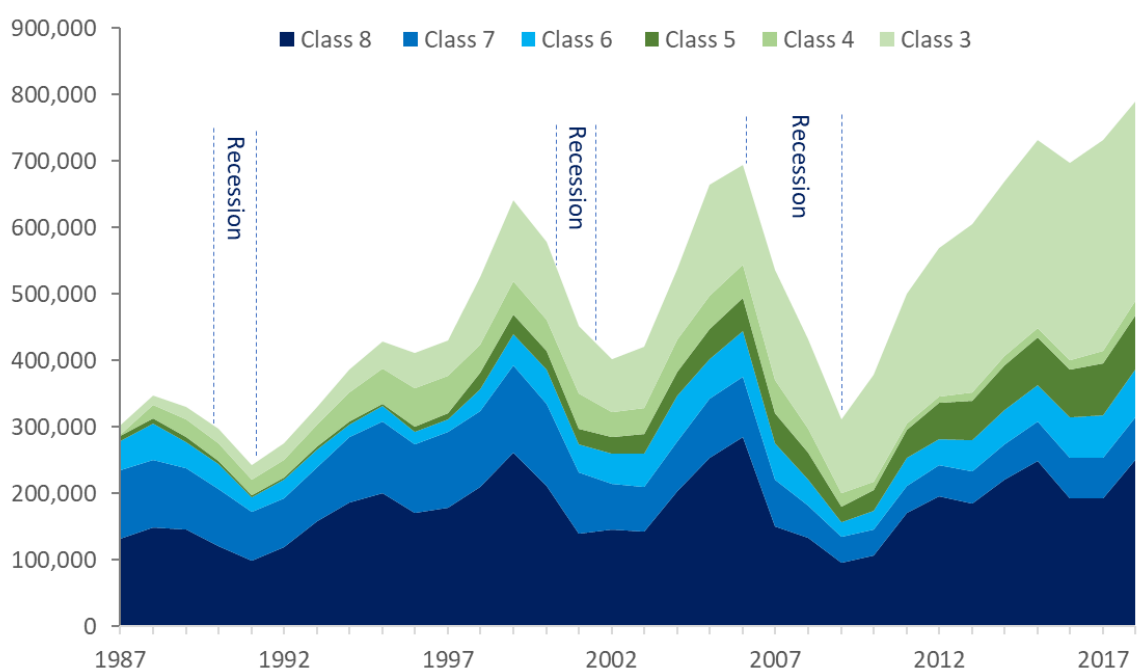
[x] See Figure 3. Source: American Truck Dealers (2020)

Over the last 30 years annual new M/HD vehicle sales have averaged approximately six percent of the fleet, while annual fleet growth has averaged about three percent—meaning that approximately three percent of the M/HD vehicle fleet turns over each year with older vehicles retiring.[13] This implies that the average M/HD vehicle life is approximately 33 years. However, available evidence indicates that annual vehicle use decreases significantly as vehicles age, so the "effective" life of most M/HD vehicles is significantly shorter, likely less than 20 years to achieve 90 percent or more of total life-time mileage, given the fact that new vehicles typically travel more miles annually than older vehicles.

Many fleets operate within an existing market that may make choosing a M/HD ZEV more difficult. Over 80 percent of truck fleets are owned by small firms with six or fewer trucks.[14] Not only do many of these fleet operators lease their vehicles, but— especially for the small freight/delivery trucking fleet operators that own their fleets — many are the secondary or tertiary owners of used vehicles. Because so few fleet operators — aside from the largest firms — own new trucks, it will likely take time for new trucks to make their way into the secondary and tertiary markets.[15] Vehicle turnover rates, procurement cycles, and ownership models are all interrelated and important considerations for ZEV deployment as they display how quickly the average vehicle will be replaced. In many cases the average vehicle's life is more than 30 years meaning that for states that are prioritizing increased M/HD ZEV deployment in the near term, market interventions including financial incentives like rebates and scrappage incentives, ZEV procurement requirements, infrastructure development among others will need to be implemented to speed up the ZEV deployment process.

Average annual sales and turnover are only part of the story, however. Long-term data shows that annual new M/HD vehicles sales are highly correlated to macro-economic conditions and fall significantly during economic recessions. This is especially true for the largest Class 8 trucks, as can be seen on a national level in **Figure 4**.

Figure 4 M/HD Truck Annual Purchases



For example, prior to 2010 annual vehicles, miles, and fuel use grew at an annual rate of 2.5 to 3.5 percent. As a result of the financial recession of 2008, annual miles and fuel use fell by 15 percent (2007 – 2010) but have since recovered. In the last decade, both have been growing at historical rates.

The market experienced a similar impact in 2020 due to the COVID-19 pandemic. Disruptions in supply chains, decreased consumer activity, and economic hardship, caused many motor carriers to pause their replacement cycles in the early days of the pandemic. Although COVID-19 was detrimental to the industry in the short-term, causing industry-wide delays, analysts and dealers do not expect long-term changes to the procurement and replacement of vehicles. For example, after a precipitous drop in retail sales of Class 8 vehicles in April and May of 2020, the overall freight market began a gradual recovery and was ultimately stabilized.[16] COVID-19 has exacerbated existing inequalities – particularly with regard to health disparities. This could place an increased focus on the environmental and air quality benefits of zero-emission vehicles, as shown in states like Kentucky and Connecticut that awarded grants for electric buses in the midst of the pandemic.[17]

Table 2 Nationwide Fleet Turnover Data

M/HD Vehicle Fleet	1990 - 2000	2000 - 2010	2010 - 2018
Annual New Vehicle Sales (percent of fleet)	5.8 percent	5.5 percent	6.3 percent
Fleet Growth (CAGR)	2.6 percent	2.9 percent	2.6 percent
Average Annual Fleet Turnover	3.1 percent	2.5 percent	3.6 percent

Source: Transportation Energy Databook (Tables 5.1-5.3)

Another significant trend seen in the M/HD vehicle market in the last 30 years has been the dramatic increase in annual sales of Class 3 trucks. 2019 sales of all M/HD vehicles were 2.9 times higher than 1990 sales, but 2019 sales of Class 3 trucks were 15.6 times higher than 1990 sales of Class 3 trucks.[18] Nationally, about 75 percent of Class 3 vehicles are pickups and vans. Class 3 vehicles represent a clear opportunity for zero-emission vehicle deployment as a number of vehicle manufacturers have announced zero-emission Class 3 models in recent years and, because of their fleet and usage patterns, have the potential to improve local air quality within densely populated areas, thereby improving human health.

ZEV Availability

Over the last decade, early investment in transportation electrification focused primarily on developing LDV models. Light-duty EV sales grew from 17,000 in 2011 to almost 330,000 in 2019.[19] In response to this consumer demand and goals for EV penetration at the state and local level, OEMs are heavily investing in electrified options, with global commitments for investments in vehicle electrification totaling more than $268 billion by 2030.[20]

In recent years, these electrification efforts have expanded to include other types of ZEVs, including hydrogen vehicles, and have also begun to influence the M/HD vehicle sector. There are only a limited number of M/HD ZEVs available today for most vehicle types. Within the M/HD EV market, around 30 medium-duty electrified models and 20 heavy-duty models are available, although many more have been announced as being in development or to be available in the near-term (see Appendix II). This is significantly more than the hydrogen M/HD vehicle market which currently is limited to only a few models in the transit bus market, although there have been a number of recent public announcements of technology development partnerships. Due to consumer demand, OEM investment, and improvements in technology and cost decline, model availability is expected to continue to grow in the coming years: analysts project that the number of electric trucks in the United States could grow from 2,000 in 2019 to over 54,000 by 2025, a 27-fold increase.[21] Globally, M/HD vehicle electrification could create a $47 billion market by 2030, reaching penetration levels of nine percent.[22]

To date, electric and hydrogen fueled vehicles represent the only ZEVs that are truly zero-emitting and therefore represent a tremendous opportunity to improve local air quality and to decrease GHG emissions.[23,xi] Some key considerations for the use of both of these technologies within the M/HD vehicle sector are described below.

Medium- and Heavy-Duty ZEVs – Market Status

Although it is a nascent industry overall, there are two segments of the M/HD vehicle market that are farther along in their development of ZEV offerings. The electric transit bus market, in particular, has been steadily growing for over a decade and is the most mature M/HD ZEV market with more than five times the electric transit buses deployed compared to electric trucks.[24] With the right combination of regulations and incentives, electric bus deployment could expand rapidly; roughly 13 percent of the country's transit agencies currently have electric buses in their fleet or have them on order, one third of transit agencies in the U.S. have committed to convert to zero-emission vehicles by 2045.[25] Today, every North American manufacturer of diesel buses also sells electric buses and those offerings will continue to grow.

Following transit buses, the electric school bus market is less developed but is progressing rapidly, with electric models available from two major manufacturers. Although penetration is low to date, this will be an important sector to electrify as school buses outnumber transit buses roughly five to one.[26]

Unlike the bus market, the vast majority of M/HD EVs are made by small, secondary manufacturers, often using a strip chassis produced by OEMs. But as demand for and attention on the M/HD vehicle market grows, large OEMs are increasingly focusing on the future of M/HD EV development.

Hydrogen—because of its high energy density, fast fueling capability, and long-range potential—has also been explored by manufacturers as a ZEV option within both the LD and M/HD vehicle sectors, with particular interest towards the larger vehicles classes when EVs face more significant charging barriers. To date, the hydrogen transportation market is significantly smaller than the EV market. The International Energy Administration estimates that globally, only 11,200 LD hydrogen vehicles are in operation and that, within the M/HD sector, approximately 25,000 forklifts, 500 buses, 400 trucks and 100 vans are in operation that utilize hydrogen.[27] Of these vehicles, only a fraction are deployed outside of China with most of the deployments in the U.S. located within California, where hydrogen fueled vehicles have been supported by state grant and incentive programs. [28] Similar to the electric sector, transit buses have been some of the first movers within this market with over 11 different hydrogen transit models currently available globally.[29]

The following sections outline the factors that will influence potential growth in M/HD ZEV adoption.

Increased Investment

Within electric vehicles, manufacturers are positioning themselves to better meet increasing demand. Peterbilt and Kenworth, subsidiaries of PACCAR, are partnering with Dana on electric truck powertrain development. The companies each launched three electric M/HD vehicle models in 2020 (**Table 3**). Navistar

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[xi] It is important to consider how the hydrogen is produced when including it is as a zero-emitting fueling option. In order to achieve the most significant emission reductions, the hydrogen will need to be produced by either a zero-emitting source (e.g., renewable energy, nuclear, etc.) or sources that are paired with carbon capture and sequestration (CCS).

has launched NEXT, an e-mobility solutions business unit that will focus on electrification in the truck and school bus markets. In California, Volvo has launched the three-year Volvo LIGHTS demonstration project to test the ability for heavy-duty, battery electric trucks and equipment to reliably move freight between ports and warehouses in Southern California. Mitsubishi, Freightliner, and Mack are also conducting demonstration programs, which may result in commercial offerings by 2022.

Table 3 Sample of Electric M/HD Vehicle Offerings

Vehicle Type	Manufacturer	Model	Weight Class	Availability	Battery (kWh)	Range (mi)
Delivery Van	Ford	Transit Electric	2b/3	2021	67	126
Delivery Truck	Kenworth	K270E	6	2020	141	100
Delivery Truck	Kenworth	K370E	7	2020	282	200
School Bus	Blue Bird	Vision	7	2020	160	120
Transit Bus	Proterra	35-ft, 40-ft	8	2020	220 - 660	Varies
Tractor Truck	Peterbilt (Paccar)	Model 579EV	8	2020	264-420	110-200
Tractor Truck	Nikola	Nikola Two	8	2022	*Undisclosed*	500-750
Tractor Truck	Tesla	Semi	8	2022	*Undisclosed*	300-500

See Appendix II for additional information.

Additionally, manufacturers that are specifically dedicated to producing electric buses, trucks, and other M/HD vehicle variants are growing rapidly. U.S.-based transit bus producer Proterra secured an investment of $200 million in October 2020 following a $150 million investment in 2018 from Daimler and others.[30] Arrival, a U.K.-based electric van manufacturer backed by Hyundai and Kia, received a $118 million investment from BlackRock in October 2020.[31]

Locally, Lightning eMotors of Loveland, Colorado, has been retrofitting buses and trucks to convert older models into electric vehicles, and is planning to scale production in the coming years. Lightning went public in 2021, reports having over 1,500 vehicles on order, and is scaling manufacturing capacity to 3,000 vehicles.

Today, most available M/HD EVs have limited range under 150 miles. In the coming years, however, manufacturers like Tesla anticipate trucks that can travel hundreds of miles in a single charge.[xii]

Within the hydrogen market, very few M/HD vehicle models exist. Due to the high current cost of hydrogen and the lack of fueling stations, the hydrogen M/HD market has been slow to scale and likely will need increased research, development and demonstration projects before it is able to reach a mature market status. A number of pilots have been deployed within California surrounding the use of M/HD hydrogen vehicles (**Table 4**) including a recently deployed project with Hyundai that looks to deploy 1,600 Class 8 vehicles within California by 2025.[32] UPS and FedEx are also testing Class 6 delivery vehicles within the U.S.

[xii] A full list of announcements can be found in the Appendix II.

Table 4 Sample of Hydrogen M/HD Pilot Projects in California

Project	Manufacturer	Number of Class 8 Trucks	Deployment Date
ZECT II	TransPower, Hydrogenics, US Hybrid, BAE/ Kenworth	6	2016-2020
Project Portal	Toyota	2	2017-2018
Shore to Shore	Toyota/Kenworth	10	2019-2020
XCIENT	Hyundai	1,600	2020-2025

Source: California Hydrogen Business Council

Production Capacity

Manufacturers across the industry are ramping up production of M/HD vehicles to meet this increasing demand. Blue Bird Corporation, a leader in school bus manufacturing, has seen its electric-powered school bus sales increase by more than 250 percent in 2020 compared with the prior year. [33] The company plans to increase annual production to 1,000 units to meet anticipated demand growth. Arrival will invest $46 million in its first U.S. microfactory in South Carolina, where it will produce 1,000 electric buses per year.

There are several high profile and well-funded startups also planning to start selling commercial M/HD EVs by 2022. Tesla expects to release an electric semi-truck in 2022 and plans to spend $1.1 billion to build its largest factory in Texas to support this production.[34] Other ZEV-specific startups like Rivian and Bollinger hope to advance the electric pickup truck market while Nikola is focusing on the heavy-duty market.

While these announcements and growth trajectories signal that manufacturers across the industry are starting to seriously invest in expanding access to electrified options, they currently have limited production capacity, producing small batches of a few hundred vehicles annually. Of the 12 major truck OEMs, only Peterbilt is selling commercial EVs today – and in limited quantities. For this reason, the most pivotal commitments for M/HD vehicle development are those made by Ford and Daimler Trucks North America (or Freightliner in the U.S.) as these are the manufacturers with the greatest market share for Class 4-7 and Class 8 vehicles, respectively (see **Figure 3** earlier).

Ford, with almost one-third of the Class 4-7 market share (**Figure 3**), has committed to producing electrified versions of the Ford F-150 pickup truck – part of the F-series, the highest-selling vehicle in the U.S. over the last ten years – and Ford Transit by 2022, part of its $11 billion investment in portfolio electrification.[35] Although the F-150 (Class 1) and E-Transit (Class 2) are not M/HD vehicles (not 2b or 3), their development, as well as that of the Rivian, Tesla, and Bollinger pickup trucks that are likely to be classified as Class 2b or 3, demonstrates important advances in the medium-duty sector.[36] These models will bring the potential of electrification to a wide variety of commercial fleets, from construction vehicles to airport shuttles to plumbing service vehicles. Ford's announcement is pivotal, as the company would revolutionize product availability due to its ability to produce vehicles at economies of scale. Ford assembled nearly half of all full-size pickups sold in the U.S. in 2019, twice as much as any competitor.[37] Ford is already preparing for mass production of the electric F-150, breaking ground at its Dearborn, Michigan plant in September 2020. Due to high interest in the all-electric Ford Transit, Ford launched a registration site for the van in May 2021 after more than 450 commercial customers expressed interest in the van. Furthermore, many Class 4-7 EVs available today use Ford's platform as the base for vehicle repowers that result in electrified options. Ford's investments will force others in the commercial vehicle space to become competitive in their offerings, already shown through Ford and Volkswagen's (VW) partnership to bring commercial vehicles to market globally.[38]

Daimler Trucks North America (Daimler Trucks) – the manufacturer with the greatest market share for Class 8 vehicles and second greatest following Ford for Class 4-7 (**Figure 3**) – launched the Freightliner Customer Experience Fleet (CX Fleet) in March 2020, a program through which Freightliner will engage at least 14 different customers who collectively represent more than 150,000 of all Class 6-8 trucks currently on the road in the U.S. to test the new CX Fleet.[39] This initiative will be influential in shaping Daimler Trucks' future electric offerings, which will contribute to their 2039 goal of selling CO_2-neutral commercial vehicles across all of their markets, including North America. Similar to Ford's production impact, Daimler Trucks announced it is converting its Portland, Oregon, manufacturing plant to produce electric Freightliners.[40]

M/HD hydrogen fueled vehicles are primarily in the research and demonstration stage and are not currently deployed at a level that would require manufacturing to be scaled to meet demand.

Additional Market Considerations

The following section highlights additional market considerations that should be evaluated when considering the future market for M/HD zero-emission vehicles.

Battery Price Reduction Potential in M/HD Vehicles

One of the greatest influences on the cost of an electric vehicle is the price of its battery pack. Between 2010 and 2019, the cost of a LDV battery pack fell from approximately $1,100 per kilowatt hour (kWh) to approximately $156/kWh. As this cost continues to decline, industry experts anticipate the price of a LDV battery pack to fall to $100/kWh, which would signal price parity with internal combustion engines, by 2023.[41] The cost of M/HD vehicle batteries, however, is still likely twice as expensive as LDV models: in a 2019 study, the Department of Energy found that full-pack battery costs for LDVs ranged from $155 to $360/kWh, but M/HD "vehicle-specific requirements such as high lifetime mileage, deeper discharges per cycle, overall ruggedness, and resistance to temperature extremes, along with low sales volumes, are likely to push costs toward the upper end of this range."[42]

Hydrogen Availability within the Transportation Sector

According to the Opportunities for Low-Carbon Hydrogen in Colorado: A Roadmap (forthcoming), for M/HD vehicles, at current diesel prices, hydrogen would only compete with a standard diesel M/HD vehicle at a price of $5-6/kg on an operating cost ($/ton-mile) basis. Towards 2030 however, with assumed improved fuel economies for M/HD vehicles and expected increase in diesel prices, hydrogen pump prices would only need to fall to $6-8/kg to become competitive on an operating cost ($/ton-mile) basis. This is foreseeable in the future as production and station costs of hydrogen fall, pushing the pump price down coupled with the greater fuel economy and equivalent weight carrying capacity of FCEVs. Unlike the EV market, hydrogen's ability to scale with the transportation market may rely heavily on its use by other market sectors—such as power and heating—in order to scale hydrogen production enough to dramatically reduce its price as a transportation fuel. As in other sectors, storing and transporting hydrogen outside of locations that have existing hydrogen infrastructure is a significant barrier to utilization.[43]

Renewable Natural Gas within the Transportation Sector

Renewable natural gas (RNG), also known as biomethane, is made by capturing and refining biogases emitted from decomposing organic materials such as food scraps, animal manure and sewage. Once refined, RNG is interchangeable with conventional natural gas and can be transported and utilized via the same pipelines and infrastructure. As a transportation fuel, RNG can replace high-carbon fuels in trucks and buses. A CEO study found that Colorado's potential RNG resources could replace approximately 140 million gallons of diesel if developed, or 24 percent of the state's total diesel consumption for transportation, eliminating approximately 1.4 million metric tons of CO_2 from fuel combustion annually.[44] RNG could be particularly suitable for Colorado's significant agricultural activities and for long-haul and heavy-duty applications. In 2019, RNG use reached 37 percent of total on-road natural gas use for the transportation sector.[45]

Fleet Appetite for New/ZEV Technology

Fleets are driven to pursue lower emitting technologies for a variety of internal and external reasons. These characteristics vary depending on the size of the fleet, whether it is publicly or privately owned, what regulatory requirements the fleet is experiencing or anticipating, and—importantly—what the functional needs and usage patterns of the fleet vehicles are and if those vehicle types currently have available lower emitting models that meet those needs. The following characteristics may influence a fleet operator's willingness to invest in new technology.

Fleet Operations and Ownership

The variability of M/HD fleet location, usage patterns, functional needs, and ownership models can complicate an operator's ability to transition to low- or zero-emitting vehicles. Fleet operators need to consider vehicle retirement criteria, model availability, vehicle cost, daily range requirements, and available/needed infrastructure when beginning to transition their fleet. Some key considerations for each of these elements are described below.[xiii]

Fleet Size

The size of a fleet—varying from a small fleet of one to two vehicles to a large national fleet of thousands—will impact a fleet operator's ability to be a first mover in the transition to zero-emission vehicles. Larger public and private fleets may face stronger internal and external pressures to transition their fleets and may also have greater access to the financing necessary to procure new vehicles and to develop fueling infrastructure. For example, publicly-traded companies with larger private fleets (e.g., FedEx, UPS) may feel greater pressure to procure zero-emission fleets from investors in order to meet environment, social, and governance (ESG) targets, whereas larger public fleets (e.g. large transit fleets) may need to respond to state and local requirements to procure a certain percentage of zero-emitting vehicles.[46] While other smaller fleets may also feel these pressures, they may be less able to pursue aggressive procurement goals due to a lack of financing opportunities and lack of staffing capacity and technological understanding to know how to move forward with zero-emission vehicle procurement. Additionally, and just as important, is the fleet operator's risk tolerance. A larger public or private fleet for example, will likely have additional vehicles that are kept as replacement, or 'spare' vehicles in case of vehicle maintenance. A smaller fleet that owns and operates only a few vehicles may have fewer spares (or none), making electric vehicles and other ZEVs —which have more limited charging and fueling infrastructure—appear riskier.

[xiii] MJB&A has conducted a series interviews with different M/HD vehicle fleet operators. The information within this section represents findings from those conversations in addition to supplemental research.

Character of the Fleet Owner and Ownership Model

Just as the size of the fleet may impact a fleet operator's ability to pursue ZEV options, its ownership model may also impact how readily a fleet is able to procure new technologies. Publicly owned fleets, for example, may face a strong state requirement to pursue cleaner options whereas privately owned fleets may electrify in order to meet sustainability or corporate responsibility goals. For certain segments of the M/HD fleet market (e.g., private local and regional trucking fleets) vehicle leasing is more common. Because these fleets are not responsible for vehicle procurement, they may face additional structural barriers (e.g., finding a firm that offers ZEV models) that may lower their willingness to pursue ZEV options. Equally, however, the large rental fleets will base procurement models and truck offerings on what their customers require.

Understanding Differing M/HD Fleet Considerations

There are a wide variety of different M/HD vehicle types that serve different functional needs and usage patterns. Many of these vehicles will have unique operating duty cycles, usage patterns, and capacity concerns that will impact 1) how readily a vehicle is able to be replaced by a zero-emitting vehicle and 2) whether the new vehicle will be able to effectively perform the function of the replaced vehicle.

These differences will vary widely from having a minimal impact on the functionality of a vehicle (i.e., a truck that is used for general operations will have different vehicle requirements when compared to a similarly sized truck that is used to plow snow during the winter) to having a significant impact on a fleet's ability to transition to ZEVs (i.e., a long-haul truck and a regionally operated delivery van will face very different barriers to transitioning to zero-emitting vehicles based upon their vehicle usage patterns and access to fueling infrastructure).

The operating environment of a fleet (e.g., whether the vehicle returns to the same depot every night, if the fleet operates regionally or nationally) will impact the amount of fueling infrastructure (e.g., EV charging equipment, hydrogen or renewable natural gas stations) that will be required to service the fleet. For EVs, the size of the vehicle and the location characteristics, like climate and topography, will also impact a fleet's ability to procure ZEVs.

As is discussed in the previous section of this report, there are currently very few M/HD ZEV models available and existing fueling infrastructure for these models is also limited. For fleet operators looking to procure ZEVs, they will have to compare their vehicle needs to what is currently available in the market to determine the feasibility of transitioning their fleet to a zero-emitting option.

Understanding Differing Charging Needs Across Fleets

As outlined previously, M/HD vehicle fleets vary widely by use case, routes, down time and other factors, which ultimately creates unique charging needs and schedules of each fleet. Most M/HD EVs are anticipated to be able to charge overnight at the depot/garage in 3-5 hours and require less than 50 kW per vehicle (**Table 5**). For transit buses, although some may utilize on-route charging during the day, they will still require charging stations that can provide at least significant power output per bus (i.e., one 450 kW charger for every six to eight buses). Long haul tractor trailers, on the other hand, will require a public/shared high-power charging network with individual chargers sized at 500 kW to 1 MW, which can be shared by up to 15 trucks (i.e., less than 100 kW per truck).

While M/HD vehicle fleet needs vary widely, all require greater amounts of power compared to LDVs with regional and long-haul tractor trucks requiring between 30 to 92 times the annual energy use of an electric passenger car.

Table 5 Anticipated M/HD Vehicle Charging Scenarios

	Class 3 Delivery Truck	Class 6 School Bus	Class 6 Truck	Class 7 Transit Bus	Class 8 Tractor	
Use	Services & Local Delivery	Fixed Route Service	Regional Haul	Fixed Route Service	Regional Haul	Long Haul
Charging Location	Depot	Depot	Depot	Depot	Depot	Public
Available Charge Time (hr./day)	10+ hr.	10+ hr.	10+ hr.	7 – 11 hr.	10+ hr.	<2 hr.
Required Charge Rate	<10 kW	<10 kW	25 – 50 kW	50 – 75 kW	50 – 75 kW	600 – 1000 kW

Source: MJB&A

Actual charging rates, times, and options will vary by specific vehicle model. Many M/HD ZEVs, as is the case for LDVs and transit vehicles, will likely have different charging options available to them, such as slower in-depot charging, as well as higher-powered fast charging options located at the depot or in public.

Existing or Anticipated Regulatory Environment

Entities at both the federal and state level have regulated diesel emissions for decades due to high $PM_{2.5}$ and NOx, both of which negatively impact human health and the environment. More recently, diesel emissions have been regulated based on their climate-warming GHG emissions impact. The regulatory environment in which the fleet operates or anticipates operating can encourage a fleet to become an early adopter of new technologies that allow the fleet to comply with a regulation and avoid paying costly fees.

The stringency of the regulation plays a significant role in a fleet operator's transition to lower emitting technologies. A fleet operator will have to weigh the expense of transitioning a fleet to a new technology with the expense of paying a fee for non-compliance. Some regulations do not offer alternative compliance mechanisms (e.g., trading credits or paying a fee) and instead require that all M/HD vehicles are zero-emitting by a target date.

Key Characteristics of Fleets Pursuing Lower Emission Vehicles

For all of the reasons outlined above, many of the M/HD fleet operators that have made fleet procurement commitments or have set targets fit into the following categories:

- Large fleets that own and operate vehicle models that currently have a zero-emission vehicle option that has either been announced or is currently available on the market (e.g., delivery companies, transit organizations);
- Entities that have strong environmental targets (e.g., large investor-owned companies with ESG standards, government owned entities);
- Fleets located in states with aggressive clean air and climate targets.

The tables in Appendix II display a sample of existing fleet procurement announcements and targets nationally. Fleets across Colorado have begun integrating ZEVs, including vehicles utilizing renewable natural gas in the City of Grand Junction, the City of Longmont, and in Waste Management's fleet in Ault.

Overview

Current Status of Medium- and Heavy-Duty Vehicles in Colorado

Meeting Colorado ZEV Goals

To begin the M/HD ZEV transition, it is important to understand the current make-up of M/HD vehicles operating in Colorado, these vehicle's contribution to state-wide emissions, what attitudes fleets have towards a ZEV transition, and the readiness of the service sector to embrace ZEVs. MJB&A prepared an overview of the current M/HD fleet in Colorado to evaluate the current status of the Colorado M/HD vehicle market.[xiv,xv]

Current Status of Colorado's M/HD Fleet

Medium- and Heavy-Duty Vehicles

There are currently more than 480,000 M/HD vehicles registered in Colorado.[xvi] These vehicles are broken down into different classes based on gross vehicle weight rating (GVWR) (**Table 6**).

Table 6 M/HD Vehicle Classification

Class	GVWR Range (lb)
2b	8,501 – 10,000
3	10,001 – 14,000
4	14,001 – 16,000
5	16,001 – 19,500
6	19,501 – 26,000
7	26,001 – 33,000
8	> 33,000

Classifications are consistent with EPA and CARB and align with the California Advanced Clean Trucks regulation.

Vehicle weight classes span a large weight range – from light commercial vehicles in Classes 2b and 3, to heavy-weight trucks weighing over 33,000 lbs. (16.5 tons). M/HD vehicles come in many configurations, some of which are tailored to various commercial applications or provided by OEM's as incomplete or semi-complete vehicles ready for secondary manufacturers to customize.

Total Population, Age and Vehicle Miles Traveled (VMT)

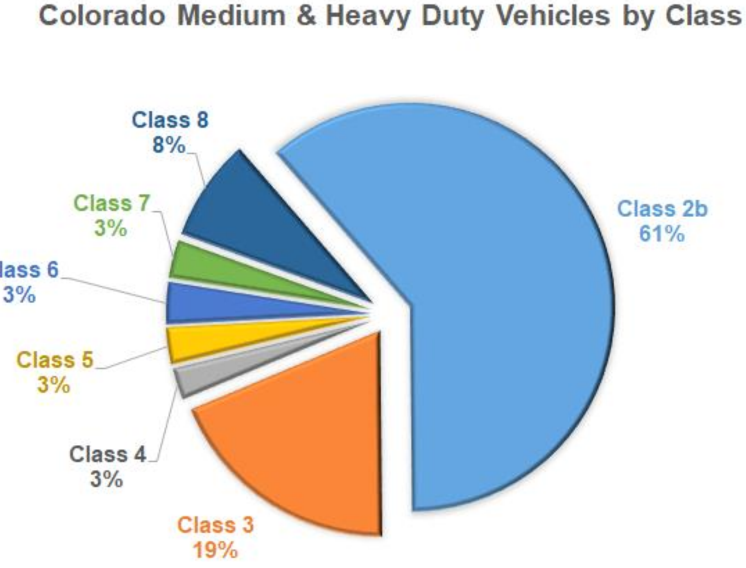
Colorado has nearly half a million M/HD vehicles operating in the state and a significant finding of the registration analysis is that over half of these are Class 2b light-trucks, with Class 3 contributing the second largest portion. Based on further review of the different data sets, it can be surmised that a very large portion of the Class 2b vehicles are either personal vehicles or are owned by very small commercial fleets. **Figure 5** shows a breakdown of Colorado's M/HD population by vehicle class.

[xiv] MJB&A used registration data purchased by CDPHE from IHS Markit as well as state-maintained fleet records to conduct this analysis.

[xv] To supplement this data and as a means to gauge fleet characteristics that are not part of an existing dataset and fleet attitudes, MJB&A prepared a survey, which CDOT distributed via stakeholder interest groups. See Appendix II for more information on the survey results.

[xvi] There are vehicles that operate in Colorado but are registered elsewhere. Discussion and analysis of vehicles is limited to those registered in Colorado for which data was made available by CEO and CDPHE.

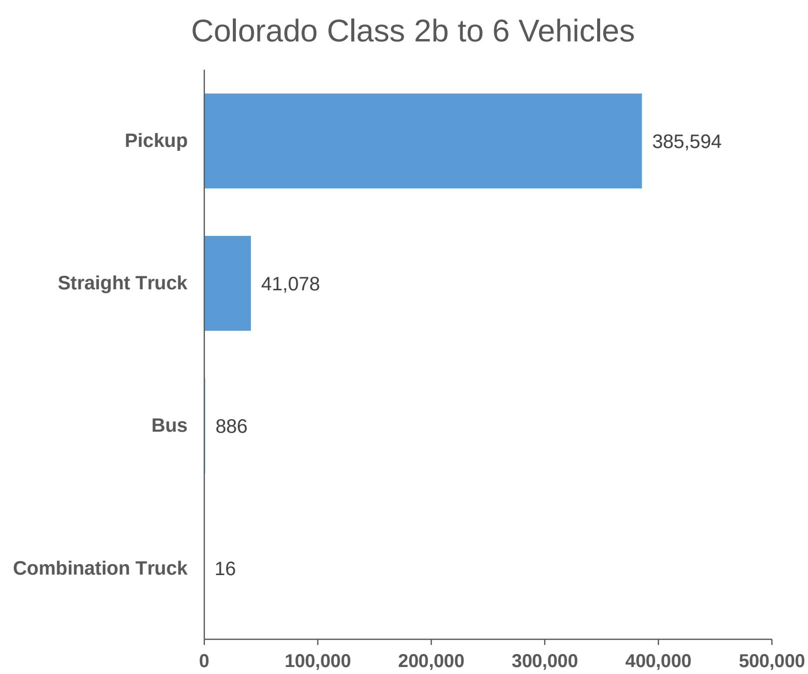
Figure 5 Colorado M/HD Vehicles by Weight Class



Class 2b makes up the largest population of the Colorado M/HD fleet at 61 percent, followed by Class 3 trucks with 19 percent, Class 8 at eight percent, and Classes 4-7 representing the remaining 12 percent. These vehicles can be broken down further into their respective vehicle types – see **Figures 6 and 7** for Colorado's Class 2b through 6 and Class 7 and 8 vehicle types, respectively.

In **Figure 6**, Class 2b and 3 pickup trucks dominate the total population of M/HD vehicles, but there is still a significant population of straight trucks, which also include cab chassis, and cutaway vans. Looking at **Figure 7**, most vehicles are in Straight Truck and Tractor Truck categories. The Straight Truck category includes fire trucks, refuse trucks, motor homes and others. Buses shown in Figure 7 includes both school and non-school.[xvii] [xviii]

Figure 6 Colorado Class 2b to 6 Vehicles



[xvii] Underlying Data for Figures 6 and 7 are from a combination of data sources provided by the CDPHE. Sources include state Department of Motor Vehicles registration data and commercially available data from IHS/Polk. These were the best data available at the time of this report.
[xviii] See Appendix 1 for more information on different vehicle types.

Many of these vehicles are clustered around large cities like Denver, Boulder, and Colorado Springs, but there are also concentrations of M/HD vehicles in counties statewide. See **Figure 8** below for the distribution of vehicles across the state.

As shown in **Figure 8** registered M/HD vehicles are concentrated in areas of higher population density. However, even areas with low population density can contain a significant number of M/HD vehicles due to the presence of oil and gas industry operations, military bases in addition to private non-fleet M/HD vehicle owners who drive class 2b-3 vehicles as their primary vehicle.

Figure 7 Colorado Class 7 and 8 Vehicles

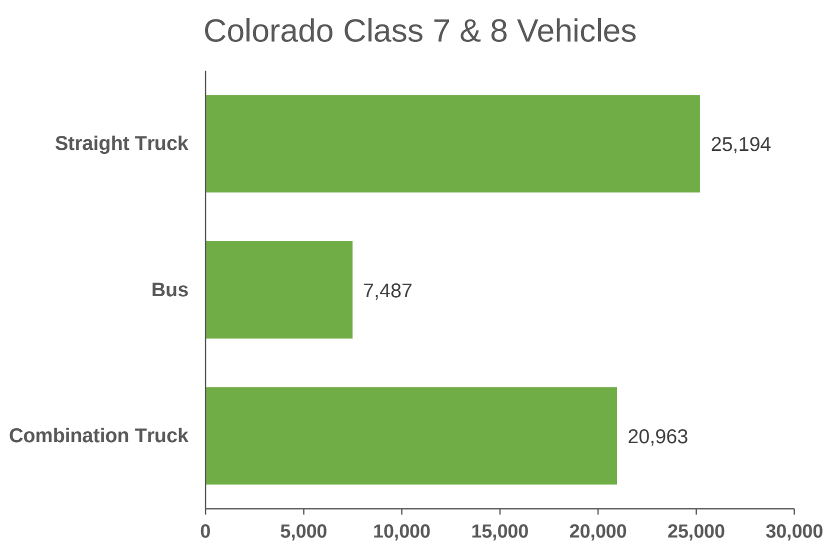
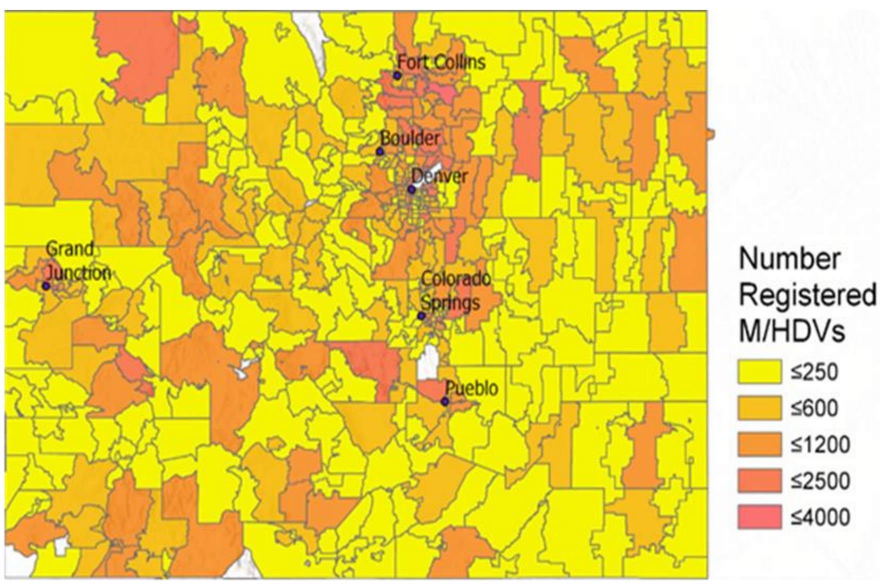


Figure 8 M/HD Registration Density by Zip Code (Class 3-8)



Number of Vehicles, Weight Class 3-8 Registered by Zip Code

The majority of freight traffic in the state is concentrated around the Denver-metro area and follows the major highway freight routes including Interstate I-70 and I-25 (**Figure 9)**.[xix]

As shown, annual average daily freight traffic is concentrated North-South on I-25, East-West along I-70, as well as a section of I-76 in the northeast corner of the state. There is much less freight passage through the southwestern part of the state due to its low population density and challenging terrain.

[xix] FHWA National Highway Freight Network data (Spring 2021)

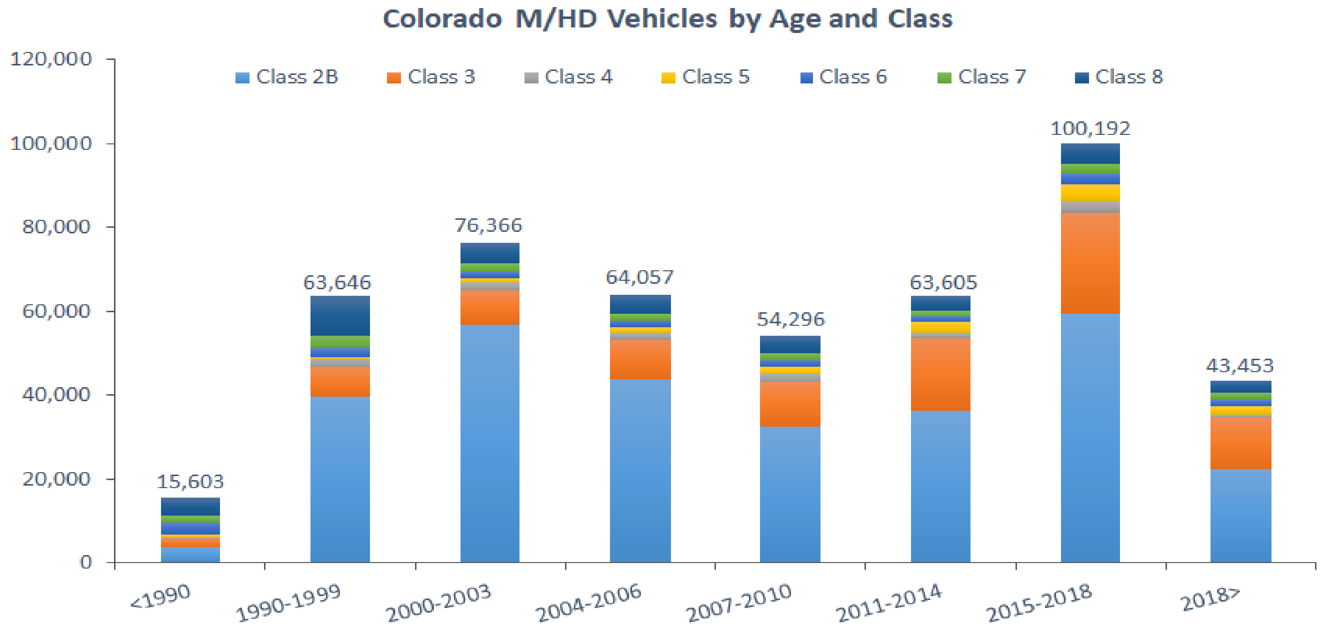
Age and Retention

M/HD vehicles are designed to handle the demanding nature of commercial operations and the heavy-hauling necessary to keep the economy moving. Due to this robust nature, purchasing new M/HD vehicles requires significant capital expenditure. Because of this, many M/HD vehicles are kept longer than LDVs. In Colorado, nearly half of the M/HD fleet is older than 14 years with approximately 16 percent of vehicles built before 2000. See **Figures 10 and 11** for the distribution of M/HD vehicles by age and class and registration distribution by county, respectively.

Figure 9 High Volume Freight Corridors

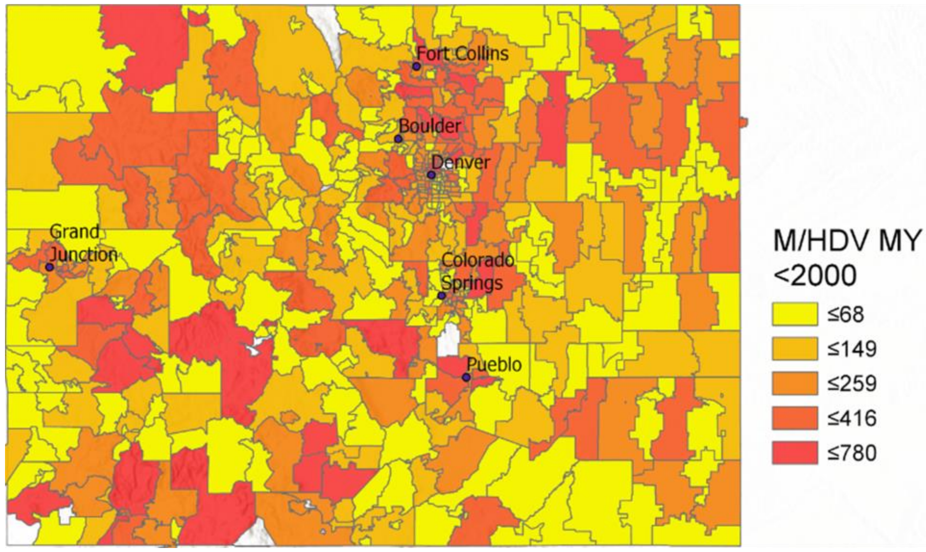
High Volume Freight Corridors by Annual Average M/HDV Traffic

Figure 10 Distribution of M/HD Vehicles by Age and Class



Close to 34 percent of the largest Class 7 and 8 vehicles are older than 20 years (pre-1999), while only 8 percent are newer than 2018. Conversely, over 30 percent of Class 2b to 6 vehicles are newer than 5 years, with about 9 percent of vehicles less than two years old.

Figure 11 Registration Distribution of Vehicles MY 2000 and Earlier



In times of recession, and most recently during COVID-19, supply chain shortfalls and negative economic impacts to fleet owners can cause vehicles to be kept for longer periods than average. Historically, new truck sales at the national level have had a downward trend every time the U.S. has faced a recession. There have also been peaks of 'pre-buy' activity that occurred just prior to new EPA emission regulations taking effect (See **Table 7** for a history of EPA and CARB regulations).[xx]

Table 7 U.S. EPA & California Emission Standards for Heavy-Duty Compression-Ignition Engines

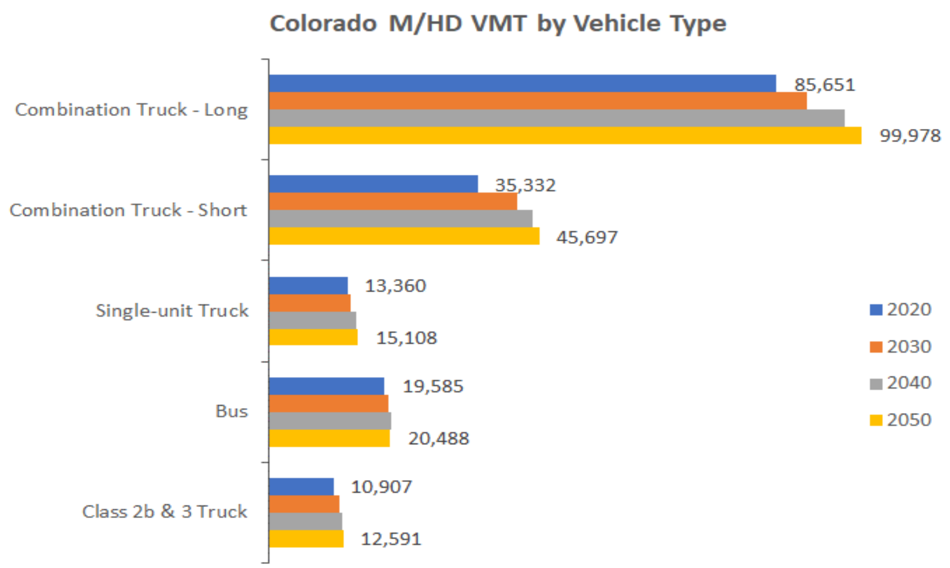
Year	Carbon Monoxide	HC	HC+NOx	NOx	PM	
					General	Urban Bus
1990	15.5	1.3[f]	-	6.0	0.60	
1991	15.5	1.3[g]	-	5.0	0.25	0.25[c]
1993	15.5	1.3[g]	-	5.0	0.25	0.10
1994	15.5	1.3[g]	-	5.0	0.10	0.07
1996	15.5	1.3[g]	-	5.0	0.10	0.05[d]
1998	15.5	1.3	-	4.0	0.10	0.05[d]
2004	15.5		2.4	-	0.10	
2007	15.5	0.14[a]	-	0.20[a]	0.01	
2015	15.5	0.14	-	0.02[b]	0.01	
2024[e]	15.5	0.14	-	0.05	0.005	
2027[e]	15.5	0.14		0.02	0.005	

Source: Diesel Net, https://dieselnet.com/standards/us/hd.php
a NOx and NMHC standards were phased-in on a percent-of-sales basis: 50% in 2007-2009 and 100% in 2010. Most manufacturers certified their 2007-2009 engines to a NOx limit of about 1.2 g/bhp-hr, based on a fleet average calculation.
b Optional. Manufacturers may choose to certify engines to the California Optional Low NOx Standards of 0.10, 0.05 or 0.02 g/bhp-hr
c California standard 0.10 g/bhp-hr
d In-use PM standard 0.07 g/bhp-hr
e California only, not applicable at the federal level.
f For methanol-fueled engines, the standard is for total hydrocarbon equivalent.
g California: NMHC – 1.2 g/bhp-hr, in addition to the THC limit.

[xx] See Appendix 1 for a full discussion of M/HD vehicle market trends.

EPA's Motor Vehicle Emission Simulator (MOVES) model was used to develop estimates of vehicle miles traveled (VMT) (**Figure 12**) and population forecasts from 2030 through 2050 (**Table 8**). MOVES VMT and vehicle population projections are based on the Energy Information Agency's 2019 Annual Energy Outlook, which classifies vehicles differently than the MOVES model, introducing some uncertainty to the following projections.[47] The model results show that M/HD vehicles in Colorado travel an average of approximately 11,000 to 85,000 miles annually (30 to 235 miles per day) depending on type, with long-haul combination trucks accumulating the most miles and Class 2b and 3 trucks the fewest (See **Figure 12**).

Figure 12 Colorado M/HD Average Annual VMT by Vehicle Type



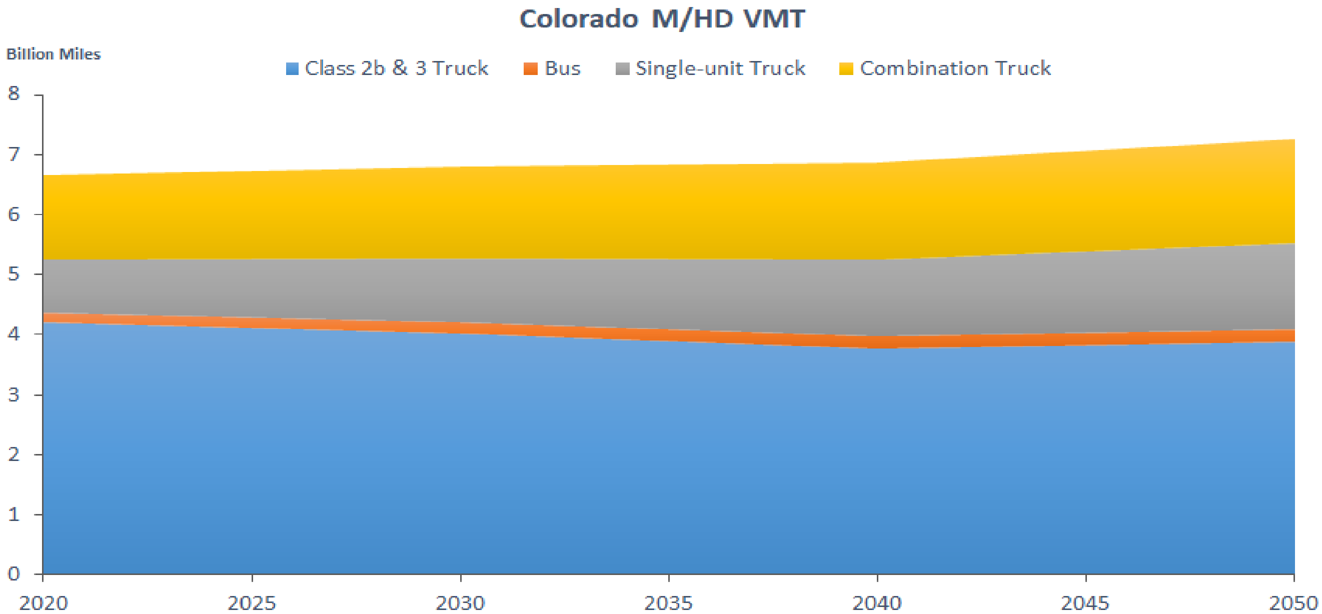
Of particular note is that projected average annual VMT increases vary considerably, with only a 4 percent increase through 2050 for most single unit trucks but a 23 percent increase for long-haul combination trucks. Using these changes in fleet population, as well as the average VMT per M/HD vehicle, total VMT for the M/HD fleet can be projected (**Figure 13**).

Total VMT for the M/HD fleet is more than 6.5 billion miles in 2020, rising to nearly 7.2 billion miles by 2050. As with the total population of vehicles, Class 2b and 3 dominate VMT with nearly 64 percent of miles driven in 2020. As shown in **Table 8**, EPA's MOVES model predicts that the population of these vehicles will decline through 2050, despite their average annual VMT increasing (**Figure 13**).

Table 8 MOVES Model Population Forecast

% Population Increase/Decrease	2030	2040	2050
Class 2b & 3 Truck	-11.9%	-21.4%	-20.2%
Bus	10.0%	19.8%	30.8%
Single-unit Truck	16.2%	30.1%	42.9%
Combination Trucks	0.1%	-0.2%	3.3%
Source: MOVES3.0, Colorado Fleet Average			

Figure 13 Colorado M/HD VMT



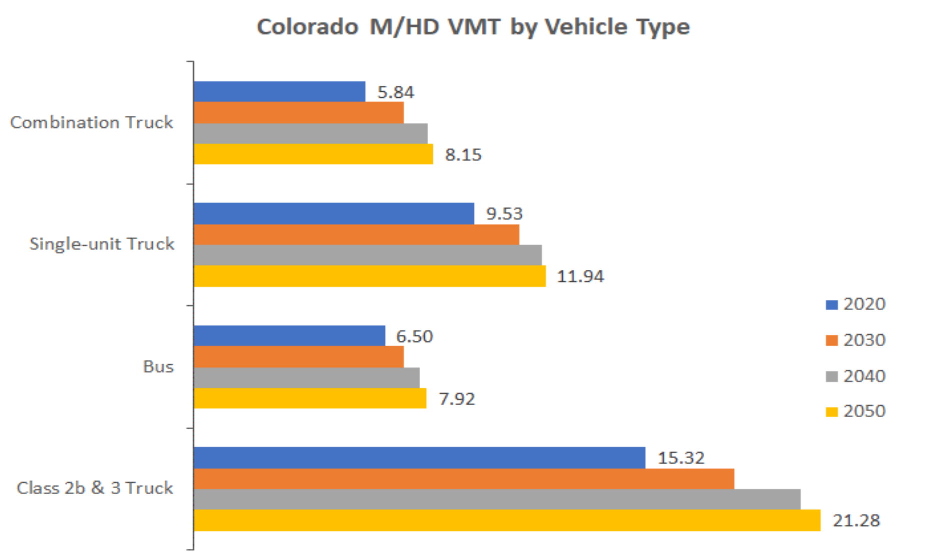
Fuel Use and Emissions

Colorado M/HD vehicles travel large distances annually, requiring significant quantities of fuel. Typically, these vehicles are fueled by gasoline or ultra-low sulfur diesel, with a small percentage of vehicles using compressed natural gas. Using EPA's MOVES model programmed for Colorado-specific information, CO_2 emissions for the different vehicle types were projected. Using CO_2 as a surrogate for fuel use, as well as an assumed 10,143 grams of CO_2 per gallon of fuel, total fuel use was calculated. Then, dividing these fuel use estimates by the total VMT forecasted for the different vehicle types, fuel economy figures in miles-per-gallon (MPG) for the different vehicle types were calculated.

Figure 14 presents blended MPG figures for each of the M/HD vehicle types. It should be noted that MOVES default fuel-type weighting was used to develop the blended fuel economy rates shown.

Fuel economy across all M/HD vehicle types is projected to increase substantially by 2050—the largest increase being from Class 2b and 3 as well as Class 8 vehicles

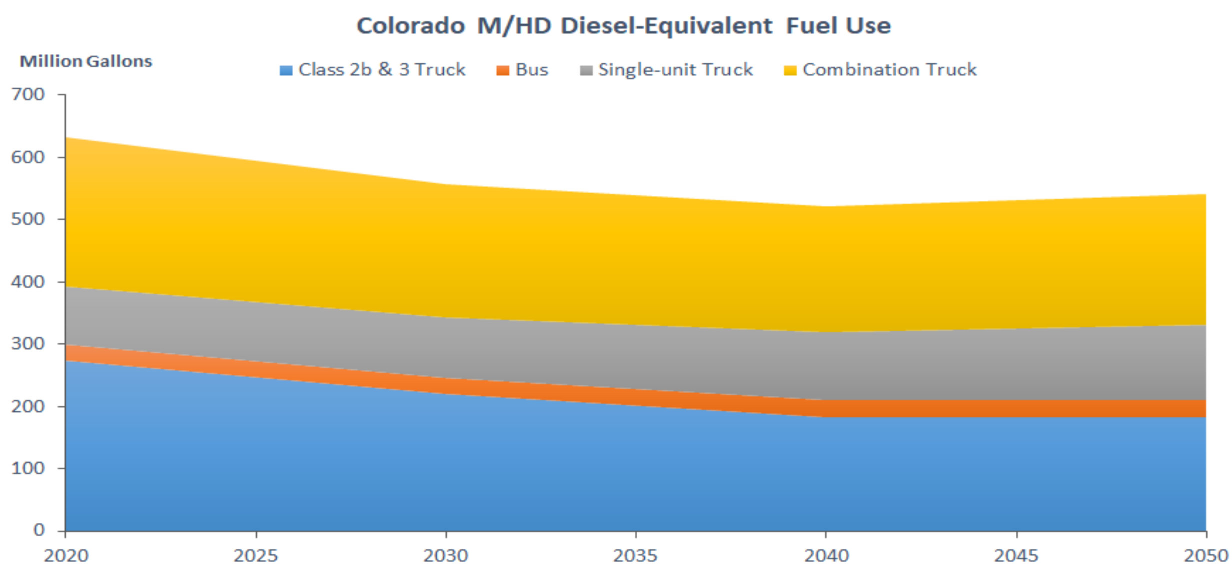
Figure 14 Colorado M/HD MPG by Vehicle Type



with a 28 percent increase in both categories. This is due to projected improvements to engine combustion efficiency as well as vehicle aerodynamic enhancements.

As discussed earlier, MOVES was queried to obtain total CO_2 emissions for the different vehicle types and then converted to fuel use using an assumed 10,143 grams of CO_2 per gallon of diesel fuel. Based on the CO_2 projections from MOVES, total diesel-gallon-equivalent fuel consumption from Colorado M/HD vehicles is approximately 630 million gallons annually, but fuel use is projected to decrease at least 14 percent by 2050 to 540 million gallons. See **Figure 15** for projected diesel-equivalent fuel consumption by the Colorado M/HD fleet.

Figure 15 Colorado M/HD Diesel-Equivalent Fuel Use



Based on MOVES' projections, Class 2b and 3 vehicle fuel consumption represents about half of all M/HD consumption in 2020, but as projections approach 2050, their percent of total M/HD fuel usage decreases to about one-third (-34 percent from current levels). Also shown is the projection of single-unit truck fuel consumption, which is forecasted to increase from nearly 93 million gallons in 2020 to almost 120 million gallons by 2050 (+29 percent), despite a 20 percent increase in fuel economy (**Figure 14**). This increase can be attributed to the rise in single-unit truck population climbing by almost 43 percent by 2050 (**Table 8**). Although speculative, this increase in single-unit trucks could be attributed to increases in populated areas and the need for larger distribution networks to meet consumer needs.

Vehicle Emissions

As discussed previously, many of the M/HD vehicles in Colorado are older than 14 years old — pre-model year (MY) 2006. With these older vehicles comes higher in-use emissions of NOx and PM compared to newer vehicles. New vehicles are required to meet more stringent emissions regulations, which help to reduce emissions of NOx, PM, and GHGs. See **Figures 16, 17, and 18** below, which illustrate current reductions in vehicle gram-per-mile emissions. It is important to note that while PM and NOx emissions have achieved dramatic reductions only very modest reductions have been achieved in GHG emissions with newer vehicles, with some categories actually having higher emissions than pre-2000 vehicles.

Figure 16 Colorado Average CO_2e Emissions Rate by Age

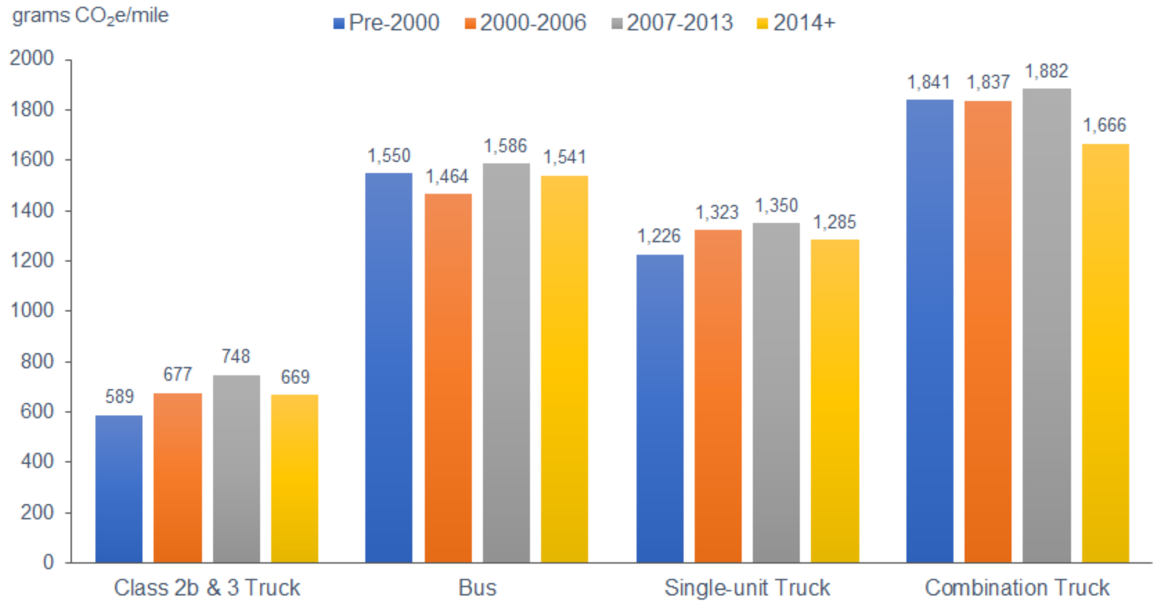


Figure 17 Colorado Average NOx Emissions Rate by Age

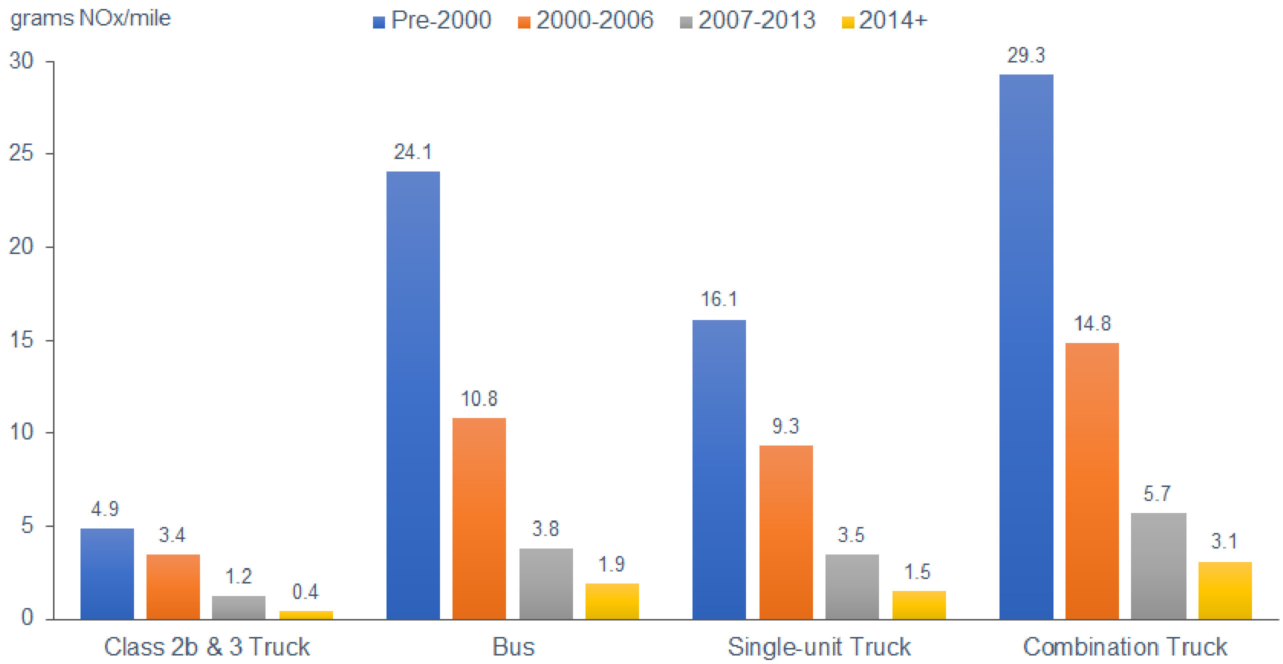
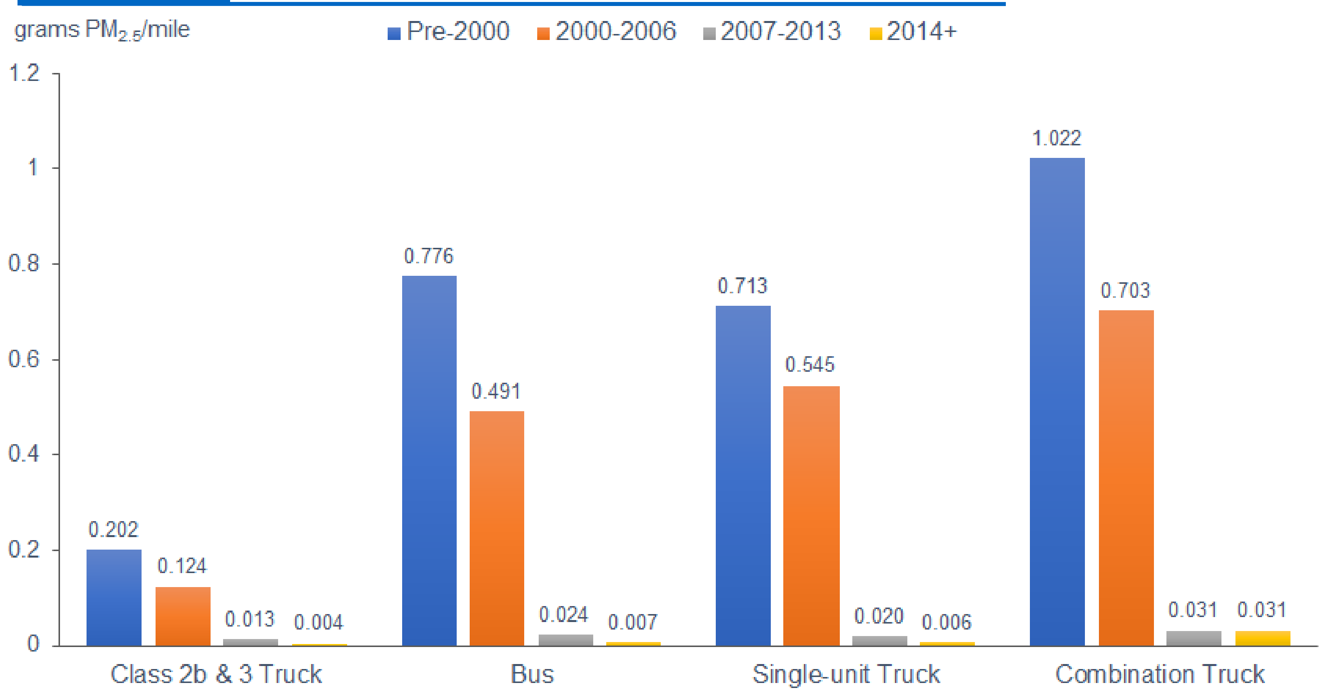


Figure 18 Colorado Average $PM_{2.5}$ Emissions Rate by Age



As shown in these figures, NOx and PM emissions significantly decrease with newer model years. This becomes particularly apparent when comparing the “2000-2006” and “2007-2013” age ranges for PM emissions. Comparing the two ranges for combination trucks, PM gram-per-mile emissions drop nearly 96 percent for trucks in MY 2007-2013, compared to MY 2000-2006.

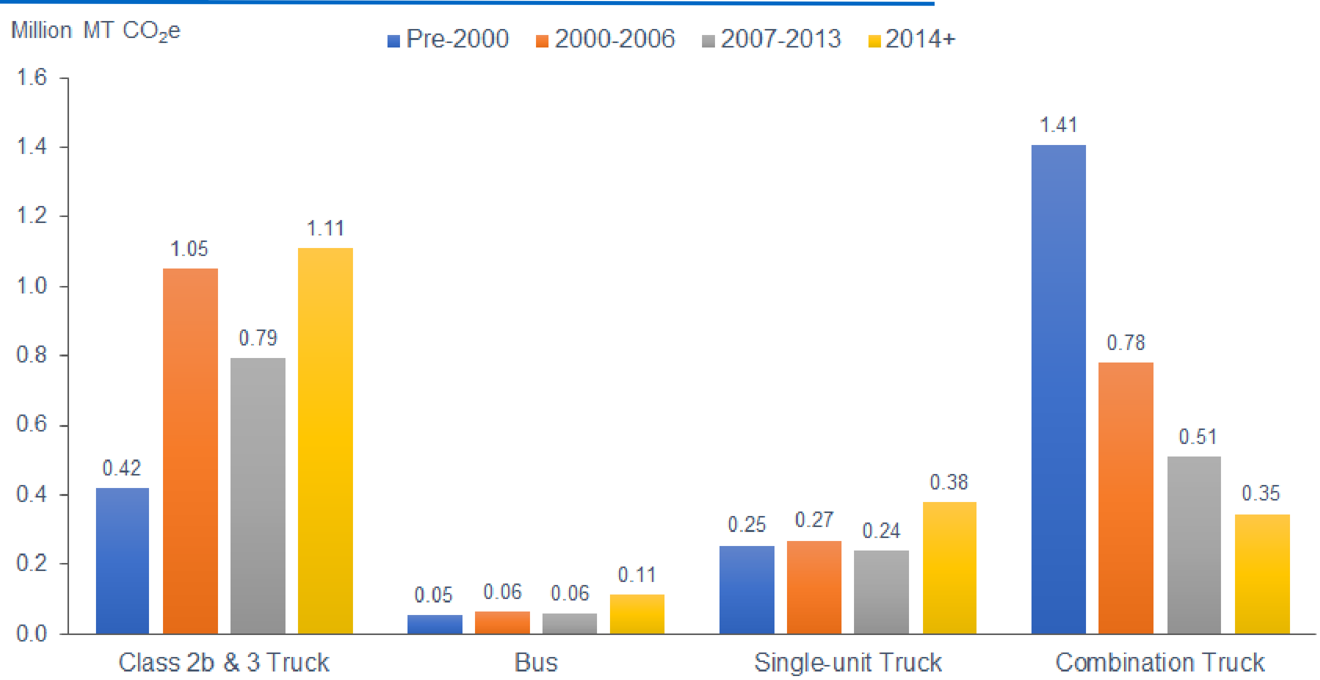
To understand the entire "lifecycle" of emissions from M/HD vehicles, it is important to include "upstream" emissions—emissions necessary to extract, process, and transport fuels for their use. This is typically referred to as "well-to-pump" (WTP) emissions. When coupled with in-use emissions (i.e., combustion of the fuel) these represent lifecycle "well-to-wheel" emissions. **Table 9** illustrates the WTP emission rates from GREET2020 for each gallon of diesel fuel for NOx, PM, and GHGs.

Table 9 Well-to-Pump Emission Rates

Pollutant	g/gallon (Diesel)
NOx	2.49
PM	0.15
GHGs	2,000.47

Using both in-use and WTP emission rates, along with population data, average VMT per vehicle as well as average fuel economy for the different vehicle types, total emissions can be estimated for the entire Colorado fleet. Lifecycle emission estimates for the different vehicle types, split by age bracket are provided in **Figures 19, 20, and 21**. It should be noted that Lifecycle CO_2e is shown in million metric tons, while NOx and PM2.5 are shown in metric tons.

Figure 19 Colorado M/HD Lifecycle CO_2e Emissions by Age



Adding up the emissions in **Figure 19**, the Colorado M/HD fleet emits almost 8 million metric tons of CO_2e as a whole, with over 80 percent of these emissions coming from Class 2b and 3, and combination trucks. As discussed previously, a significant portion of combination truck emissions is attributable to trucks manufactured prior to 2000.

Looking at **Figure 20**, NOx emissions amount to over 43,000 tons for M/HD vehicles, with more than half coming from pre-2000 combination trucks. This trend can also be seen for $PM_{2.5}$ emissions as shown in **Figure 21**—$PM_{2.5}$ emissions in Colorado from the M/HD fleet represent nearly 1,600 tons, with almost 1,000 tons coming from combination trucks and about two-thirds attributed to vehicles older than 2000.

Figure 20 Colorado M/HD Lifecycle NOx Emissions by Age

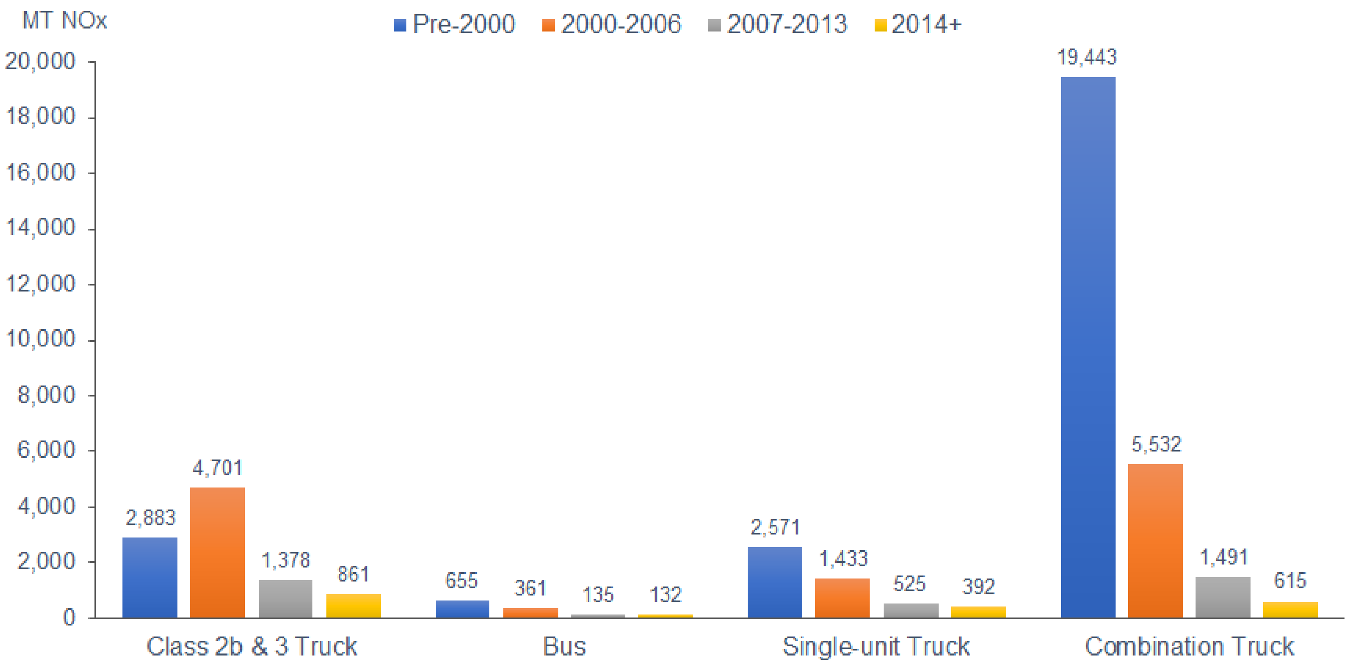
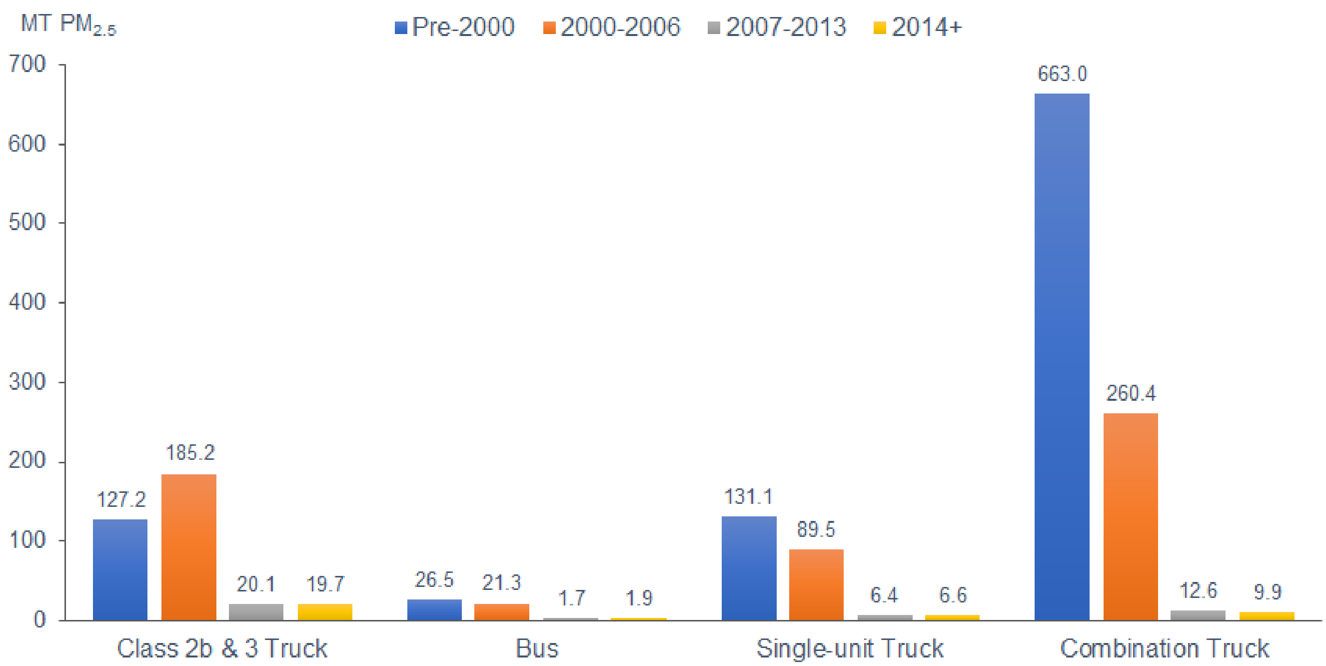


Figure 21 Colorado M/HD Lifecycle $PM_{2.5}$ Emissions by Age

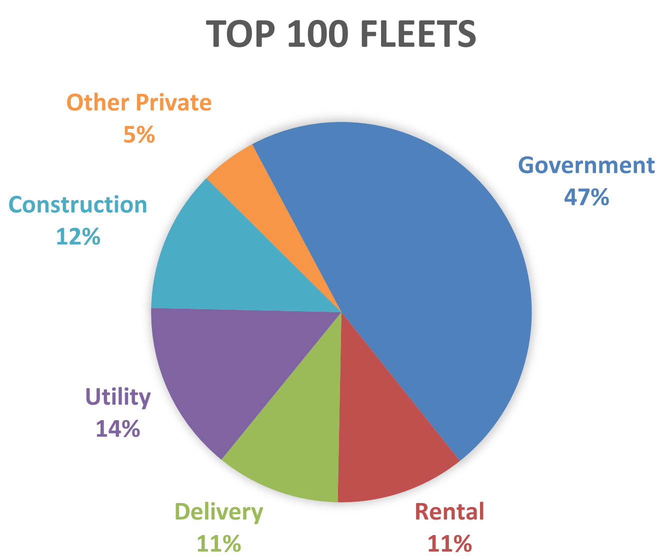


Fleets Around Colorado – 100 Largest Fleets

State, county, and city governments, including transit authorities and school districts, own about half of the vehicles in the 100 largest fleets in Colorado, as shown in **Figure 22**. Collectively, the vehicles in these 100 largest fleets comprise about 6 percent of the M/HD vehicle sector. Utilities, including electric companies, telecommunication companies, and water and waste authorities, make up an additional 14 percent of vehicles. Truck rentals, and delivery service vehicles constitute approximately 11 percent each. Construction vehicles comprise about 12 percent.

Of the largest 100 fleets, the Regional Transportation District (RTD) is the state's largest, with over 1,600 M/HD vehicles. The district provides extensive bus service in eight counties across 2,342 square miles in the Denver-Aurora combined statistical area.[48] Individual rental companies comprise the second-, sixth-, and twelfth-largest fleets and combined own almost 2,800 vehicles in the state. Last-mile delivery fleets also represent a significant number of vehicles, both as direct-owned vehicles that may operate at multiple warehouse locations as well as those contracted with independent delivery organizations for last-mile operations. Colorado Springs Utilities is the eighth-largest fleet in the state and the largest of any utility with nearly 850 vehicles. State, county, and city entities, which include Jefferson County, the City and County of Denver, the Colorado Department of Transportation, and the State Division of Central Services, all own fleets with more than 500 vehicles. The two largest school district fleets, Denver Public Schools and Cherry Creek School District, each have more than 400 vehicles. And among vocational trucking, the largest construction-oriented fleet comprises 342 vehicles.

Figure 22 Top 100 Colorado M/HD Fleets by Type



Timeline and Benchmarks for M/HD ZEV to Reach Cost/Performance Parity

Currently, there are significant cost differentials for ZEV technology compared to internal combustion engine (ICE) vehicles for both vehicle and infrastructure costs. This discussion acknowledges the need for infrastructure investments, whether by the fleet or with public support, but focuses on the need for advancement in vehicle technology.

A recent assessment estimates a range of current and 2030-projected ZEV-ICE cost differentials (i.e., the difference in upfront capital cost between a ZEV and ICE vehicle) across vehicle classes 3-8.[49] The current cost differentials range from 100-300 percent for battery-electric trucks in different weight classes and 200-264 percent for Class 8 hydrogen fuel cell-electric trucks. By 2030, however, many ZEVs are projected to approach cost parity with ICE vehicles, with estimated incremental costs for most ZEVs less than 30 percent and some as low as only four percent (Class 4/5 short-haul). Hydrogen fuel cell Class 8 trucks are projected to have a capital cost differential of approximately 15 percent by 2030. However, in addition to capital cost, parity must consider range as well as the total cost of ownership – taking into account fuel and maintenance savings.

It is generally regarded that hydrogen M/HD vehicles can achieve range parity with diesel; however, they still require significant development and deployment of technologies to further prove out lifetime durability (e.g., how frequently rebuilds are needed for diesel compared to hydrogen, where the cells within the fuel cell would require replacement). Infrastructure development and the fueling supply chain must also be further developed.

The electric M/HD price parity examples shared above also do not directly address range—something that active and future pilot projects will help prove out. As an example, in a current Class 4 market offering, the FUSO eCanter is marketed with a range of up to 80 miles per charge; if charged only once per day, this range would cap annual miles at approximately 25,000, which although more than twice the current Colorado fleet average, may be lower than the estimated need depending upon vocation. This may mean that a fleet operator could require more ZEVs, at least initially to meet the same service demands as their current diesel fleet.

Beyond capital cost and range, a third significant variable will impact the ZEV transition – treatment of residual value. Residual value for current diesel M/HD vehicles is reasonably predictable, which promotes a robust used truck market where a vehicle may be owned by three or more different companies before reaching its end of life. However, with ZEV M/HD vehicles, the residual value after 3 – 5 years in service is a significant unknown and a potential deterrent to investing in these vehicles for some fleets. Creating additional incentives and programs for fleet operators that lessens the impact of the short-term market uncertainty might be necessary to allow fleet operators to invest in ZEVs while the market is still developing.

To meet Colorado’s goal of having a 100 percent ZEV transportation sector by 2050, significant uptake of ZEV purchases must occur by 2030. The following sections outline policy options that could be developed within the state of Colorado that could start to address some of these important price and range considerations.

Policy Considerations

Strategies to Increase the Deployment of M/HD ZEVs

To date, policies focused on reducing emissions from the transportation sector have primarily been designed to reduce pollution by either requiring (through vehicle emissions standards) or encouraging (through vehicle incentive or scrappage programs) cleaner light-, medium- and heavy-duty vehicles. Transitioning the M/HD vehicle sector to ZEVs will be a significant undertaking, which will require a streamlined and coordinated approach from key stakeholders throughout the vehicle value chain.

The State of Colorado can play a key role in the execution of this strategy by:

- **Developing coordinated policy:** Colorado should continue coordinating efforts among state agencies and pivotal players in the ZEV industry (e.g., fleet owners and operators; OEMs; utilities; local groups, experts, and residents; community colleges, among others) in order to set predictable goals and targets for OEMs, utilities, and other key stakeholders to plan toward.
- **Developing clear regulatory frameworks and long-term policies:** Fleet operators struggle to understand and plan for a ZEV transition without consistent requirements and policies. This uncertainty can be minimized with clear regulatory and long-term policy. As will be discussed later on in the utility section of this report, sequencing critical grid investments, future proofing, and resilience planning are more achievable with transparent targets and consistent market signals. In establishing regulatory frameworks and long-term policies, the state should also consider how best to align with fleet purchasing cycles to ensure coordinated timing of major decisions and planning.
- **Developing incentives to encourage ZEV procurement:** It is important to pair requirements with incentives to increase adoption by making ZEV costs more manageable. To drive broad fleet transitions to ZEVs at scale, the state should look beyond vehicle total cost of ownership and address the wider set of challenges to fleet transitions such as the need for fleet-specific ZEV transition plans, existing M/HD vehicle business model constraints and other soft costs (e.g., administrative fees, siting constraints, among other costs or processes that unintentionally delay ZEV deployment or infrastructure development) associated with the transition to ZEVs.
- **Utilizing utility and OEM expertise and developing technical expertise in ZEVs:** The M/HD ZEV market is relatively nascent and will require new technical expertise that must be developed through a myriad of approaches—including pilots, demonstrations, and workforce training—in order to develop a sustainable marketplace for ZEVs within the state. Utilities and OEMs alike will be instrumental in providing unique insights into how to prepare for shifting use cases and technology deployment.
- **Creating opportunities for fleets to share experiences and lessons learned:** Developing networks for fleet operators to learn from their peers through fleet-to-fleet relationships can help them navigate ZEV integration. Colorado's Freight Advisory Council and the Colorado Electric Vehicle Coalition offer communication channels for stakeholders across the state. Nationally, coalitions like EV 100 [xxi] bring together leading companies that commit to electrifying their fleets and installing charging infrastructure.
- **Evaluating ways to streamline fueling experiences and costs for fleets operating across the state**: State leadership should support ZEV regional and long-haul trucking by working with key stakeholders to provide technical assistance to regional corridor planning exercises that will enable

[xxi] EV 100 is a global coalition; however, collaborates with U.S.-based companies and organizations.

key stakeholders to be part of the discussion to ensure ZEV deployment is not limited by technology or location within the state.

This section focuses on a variety of policy levers and approaches to scale M/HD ZEVs providing a high-level evaluation of policy approaches based on their emissions, economic impact, equity considerations, and ease of implementation. The approaches considered are outlined in the box below. Due to the nascency of the M/HD ZEV market, it is not always possible to highlight examples or lessons learned from specific M/HD ZEV programs or pilots. This section therefore highlights a combination of policy approaches that have been deployed to reduce emissions in the transportation sector, to deploy M/HD ZEVs and, in some cases to highlight examples of policies that have increased the deployment of light-duty ZEVs that could be applied to the M/HD ZEV market.

Approaches Considered

This section covers seven buckets of policy approaches and their subcomponents:

- **Mobile Pollutant Source Strategies and Other Sector Specific Strategies**
  - *On Road Vehicle Emissions Reduction Standards*
  - *Warehouse and Idling Provisions*
  - *California Advanced Clean Trucks Rule*
  - *California Heavy-Duty Low NOx Omnibus Rule*
- **Financing Solutions**
  - *Incentives*
    - *Tax Credits and Fees*
    - *Rebates*
    - *Voucher Incentive Programs*
  - *Road Pricing*
  - *Zero and Low Emissions Zones*
  - *Additional Financing Solutions*
- **Procurement Provisions**
  - *Public Procurement Policies*
  - *Private Procurement Policies*
- **Curb Management**
- **Land Use and Planning**
  - *Regional and Local Corridor Planning*
  - *Zoning and Permitting*
  - *Flexible Mobility Planning*
- **Infrastructure Development**
- **Market Based Policies**
  - *Cap and Invest*
  - *Fuel Standards*

Each policy bucket also provides context of relevant programs and programs under consideration in Colorado, including links to Colorado’s 2020 EV Plan as well as key stakeholders.

Mobile Pollutant Source Strategies and Other Sector Specific Strategies

To address the growing emissions concerns associated with transportation, many states consider mobile source pollution as either part of their Clean Air Act State Implementation Plans (SIPs) or as part of other air quality considerations. With its elevated ozone and other pollutant levels along the Front Range, the state of Colorado, local and regional partners have implemented a number of policies and programs meant to reduce pollutants that lead to poor air quality and impact human health (See Colorado's Existing Programs for more information).

More recently, Federal and state entities have started to evaluate vehicle emission impacts not only in the context of human health and the environment but also to reduce GHG emissions. For M/HD vehicles, a number of these policies and reduction programs stem directly out of the EPA and the National Highway Traffic Safety Administration (NHTSA) 2011 heavy-duty national program, which applied to both GHG emissions and fuel economy standards for on-road heavy-duty pickup trucks, vans, and vocational vehicles for MY 2014-2018. EPA and NHTSA expanded these standards in 2016 to include certain trailers and semi-trucks, large pickup trucks, work trucks, vans, and all buses for MY 2021-2027. These regulations often vary, targeting several different sources, criteria pollutants, and location-based

Relevant State Programs and Programs Under Consideration

Colorado's Existing Programs

Ozone Non-Attainment

In December 2019, EPA reclassified the Denver Metro/North Front Range ozone area from a Moderate to a Serious non-attainment area. Vehicles are the largest source of NOx, one of the two main precursors to ozone formation.

Clean Air Act Section 177 State

Following Governor Hickenlooper's 2018 directive that the Air Quality Control Commission consider a proposed rule adopting the Low Emission Vehicle (LEV) standard, Governor Polis directed CDPHE in 2019 to adopt the Zero Emission Standards (EO 2019 002). All new light-duty and medium-duty vehicles sold within the state must meet California LEV Standards for MY 2022 and ZEV Standards for MY 2023.

Public Fleet Emissions Reduction Targets

Governor Polis directed all state agencies and departments to reduce GHG emissions from State vehicles by at least 15 percent by the end of FY 2022-23 from a baseline of FY 2014-15 or at least 7.5 percent by the end of FY 2022-23 for vehicles categorized as special use (EO D 2019 016).

Idling provisions

Colorado's State Idling Standard prohibits commercial on-road diesel vehicles with a GVWR of greater than 14,000 lbs. from idling for more than five minutes within any 60-minute period. Various cities and counties have additional regulations.

Colorado's Vehicle Anti-Idling Policy for State Agencies prohibits vehicles in the state fleet from idling for more than one minute in any period for gasoline-powered or diesel-powered vehicles.

Vehicle Emissions Testing

The State of Colorado requires a number of counties within the state to require residents to show proof of an emissions test prior to registering their gasoline and diesel vehicles.

Multi-state M/HD ZEV MOU

In July 2020, Colorado signed a multi-state Memorandum of Understanding to work collaboratively with fifteen other jurisdictions to advance the market for electric trucks and buses. As a result, state agencies began exploration of clean truck policies, including California's Advanced Clean Trucks standard.

CEO EV Plan Tasks

CEO, CDOT, CDPHE, and RAQC to develop an electrification strategy for M/HD sector by July 2021, to include evaluating the adoption of a Clean Truck Rule.

CEO to develop and host an EV registration tracking dashboard.

CDOT to develop a Performance Data Warehouse consisting of a telematics database and analysis tools to monitor the deployment and performance of electric transit vehicles.

Key Stakeholders

RAQC, CDPHE, CEO, state legislature

emissions (e.g., emissions from industrial operations, warehouses, etc.), utilizing both statewide EPA-approved rules and sub-state air agencies rules to address emissions related to the movement of goods.

EPA's allowance for California to seek a waiver to develop more stringent motor vehicle emissions standards under the Clean Air Act has enabled the State of California to take a leadership role in developing zero emission rules designed to reduce emissions from the M/HD sector. Since 2012, the State of California has implemented several air quality regulations that focus on a wide variety of transportation related pollution sources in an effort to reduce GHG emissions under the state's Advanced Clean Cars program. Additionally, the state has implemented two important rulemakings; the Advanced Clean Trucks Rule and the Heavy-Duty Low NOx Omnibus Rule. Both of these rulings are designed to address M/HD vehicles' emissions in distinct and complementary ways—with one program focused on developing a market for new M/HD ZEVs by requiring manufacturers to sell an increasing share of ZEV trucks over time, and the other designed to ensure reductions in air pollution emissions from the remaining non-ZEV new trucks that are sold.

By addressing both local harmful air pollution in the short-term and developing a supply chain for zero-emitting trucks, the state is considering the immediate and long-term needs of communities located in heavily trafficked areas. The California Air Resources Board (CARB) estimates that both of these policies will dramatically reduce emissions and improve air quality. Notably, CARB anticipates that the Heavy-Duty Low NOx Omnibus Rule is expected to reduce harmful NOx emissions per new vehicle sold in California by about 75 percent below current standards beginning in 2024 and 90 percent below current standards in 2027, resulting in more than 24 tons per day once it is fully phased in by 2031.[50] The following section highlights specific provisions that Colorado has taken to address emissions from M/HD vehicles. Provisions that the State of California has taken as part of the state's advanced clean vehicles policy approach are also featured; they can serve as an example which can be incorporated into Colorado's SIP or via indirect source rulemaking.

Components

- **Enhance monitoring of air quality and emissions in disadvantaged communities**: Data collection can help to evaluate the impacts of climate policies on air quality, especially at the local level.
- **Pair emission approaches that address near term vehicle pollution with long-term ZEV goals**: It is important to implement policies that not only encourage the longer-term fleet turn-over to more efficient vehicles, but to also provide policies that reduce other mobile source pollutants like PM and NOx that disproportionately impact low-income and environmental justice communities.
- **Ensure that vehicle emission reduction and ZEV deployment strategies are paired with policies that help key stakeholders achieve targets:** Pairing requirements with incentives to increase adoption help make ZEV costs more manageable.

On-Road Vehicles Emission Reduction Standards

In 2018, the Colorado Air Quality Control Commission adopted California's vehicle emissions standards as they relate to light- and medium-duty vehicles. This applies to new vehicles, starting in 2022.

California has a variety of regulations focused on on-road vehicles within the state that reduce PM, NOx, and other criteria pollutants from heavy-duty diesel fueled vehicles.[51] Notably, the state requires heavy-duty fleets to phase in 100 percent MY 2010 emission standard engines by 2023.[xxii][52] California provides a different phase-in schedule for drayage trucks through January 1, 2023, after which the 100 percent MY 2010 engine requirement of 13 CCR 2025 applies.[53]

Warehouse and Idling Provisions

These are examples of indirect source rules that can be used to influence the direct emissions from M/HD vehicles by focusing on industrial facilities and operational requirements.

In California, the San Joaquin Valley Air Pollution Control District Indirect Source Review requires preconstruction permits, operating permits, and emission reductions during construction and operation of new buildings and structures (e.g., 25,000 ft^2 of light industrial space, etc.), including by using cleaner engines and fleets. Emission reduction targets for construction require 45 percent lower PM and 20 percent lower NOx than the California average, and 10-year operation emission reduction targets require 50 percent lower PM_{10} and 33.3 percent lower NOx than unmitigated operations.[54] The state has also deployed an airborne toxic control measure to limit diesel-fueled commercial motor vehicle idling.[55]

California Advanced Clean Trucks Rule[xxiii]

The Advanced Clean Trucks Rule focuses on developing a market for zero-emission M/HD vehicles by (1) requiring manufacturers of Class 2b-8 vehicles to sell zero-emission trucks at an increasing percentage of their annual California sales from 2024 to 2035, and (2) requiring large employers and fleet owners to report their existing fleet operations. California is also developing a partner regulation to the Advanced Clean Trucks Rule that will require all M/HD vehicles to be 100 percent zero-emissions by 2045, per Executive Order N-79-20.

Setting Requirements for Early and Consistent Coordination Between Utilities and Fleet Operators: California's Utility Notification and Large Fleet Reporting Requirements

The siting and construction of electric vehicle infrastructure can take over a year to deploy even when developed in a streamlined and coordinated way. Depending on the site characteristics and the number of vehicles, chargers, and number of other locations ahead of a particular project can further delay charging infrastructure. Fleet operators who are unaware of this timeline may procure an electric vehicle only to find that they will be unable to charge it for years. It is essential that fleet operators engage early and often with their utility to make sure that they will be able to develop adequate charging to meet fleet needs.

States can take a leadership role in requiring fleet operators to notify utilities at the beginning of their electrification process. The State of California has taken multiple steps to enable utilities and other stakeholders to evaluate both near- and long-term fleet electrification trajectories. The state requires that a customer notifies their utility of any electrical additions or upgrades at their facility regardless of the scope or scale. This requirement makes sure that utilities are engaged early in the infrastructure process so that they can help their customers better understand what their infrastructure needs are. As part of the Advanced Clean Trucks Rule, the state has also required that large entities complete a survey detailing their existing M/HD fleet characteristics and contracted services to enable the state to better understand procurement goals and vehicle estimates. While this type of survey will not display exactly how and when a fleet electrifies, it can provide useful context for utilities and other stakeholders looking to prepare for future fleet electrification.

[xxii] Affected vehicles are those that operate on diesel-fuel, dual-fuel, or alternative diesel-fuel that are registered to be driven on public highways, were originally designed to be driven on public highways whether or not they are registered, yard trucks with on-road engines or yard trucks with off-road engines used for agricultural operations, both engines of two-engine sweepers, school buses, and have a manufacturer's gross vehicle weight rating (GVWR) greater than 14,000 pounds (lbs.).

[xxiii] Of note is that in Spring 2021, New Jersey announced the intent to promulgate and enact CA ACT legislation by the end of 2021, a very aggressive timetable.

There are several key elements to the CA Advanced Clean Trucks Rule that would need to be considered in a regulatory proceeding if Colorado decides to opt into California's rule. The ACT rule utilizes a credit system that allows manufacturers some flexibility for achieving compliance, including overcoming sales deficits in one category of vehicle with surplus sales in one or more other classes, enabling banking credits for a certain number of years, and allowing credit trading between manufacturers. A detailed analysis of the likely purchase trends and ZEV market availability by vehicle class by year is beyond the scope of this report; however, it is encouraging that with developments in the Class 3 market, which makes up a significant portion of the Colorado fleet, that a credit scheme can be successfully implemented. The state would also, through a regulatory process, need to determine its own compliance start date.

California Heavy-Duty Low NOx Omnibus Rule

The Heavy-Duty Low NOx Omnibus Rule increases exhaust emissions standards and test procedures, requiring new engines to be approximately 75 percent below current NOx standards beginning in 2024, and 90 percent below current standards in 2027. While discussed frequently in the context of the CA ACT rule, it is a separate rule and can be considered and implemented separately by Colorado.

Financing Solutions

Traditional approaches to financing ZEVs have focused on bringing down the total cost of ownership to make ZEVs competitive with established ICE models, focusing mostly on capital and fuel costs. Federal, state, and local programs have implemented grant, incentive, and voucher programs to reduce the capital cost of the vehicle. For M/HD vehicles, public funding to date has been largely deployed to implement scrap and replace programs and to reduce vehicle idling.

For certain markets, public support has targeted pilot programs and small-scale initiatives. While important—for example, the cost of a new electric M/HD vehicle, could be double or triple its diesel counterpart—additional financing solutions will be needed to help scale M/HD ZEV adoption.[56]

Public finance must be used in new ways to maximize future "evergreen" funding that pairs investments from both public and private stakeholders to support larger-scale fleet transitions. As many existing funding programs—supported through programs like the VW Settlement fund—are diminishing over time, Colorado will need to leverage sustainable funding sources to preserve, improve, and expand the state's existing infrastructure and encourage innovation to build out a vibrant, low carbon transportation system that benefits all Coloradans. Through SB21-260, $5.3 billion in transportation funding will be allocated to a variety of funds, including the Multimodal Transportation and Mitigation Options

Relevant State Programs and Programs Under Consideration

Colorado's Existing Programs

Tax Credits

Colorado offers tax credits for purchasing, converting, or leasing light-, medium-, and heavy-duty plug-in electric vehicle and alternative fuel trucks. The credits decrease over time until they phase out in 2023 and 2026, respectively. Federally, the 30D tax credit offers up to $7,500 for light-duty EVs but none for M/HD vehicles.

Air Quality Programs

Clean Air Fleets is a public-private initiative of RAQC through Congestion Mitigation and Air Quality Improvement funding to improve local air quality across the Denver Metro Area/Northern Front Range through a variety of programs that reduce ozone precursors, including:

-**ALT Fuels Colorado:** Incentivizes the replacement and scrappage of pre-2009 Class 4-8 vehicles with alternative fuel vehicles.

-**Diesel Retrofit:** Helps on- and off-road diesel operators voluntarily reduce diesel emissions while saving money.

M/HD Vehicle Replacement Programs

Transit Bus Replacement: CDPHE awarded Transit Bus Replacement Program grants in 2019 and 2020.

Colorado Clean Diesel Program: Provides grants to businesses to help offset the cost of replacing certain diesel equipment with BEV or HEV-equivalent, including bucket trucks and tractors, by leveraging VW and DERA funding.

EV Fee

Colorado has an EV tax of $50; $30 is credited to the Highway Users Tax Fund and $20 is credited to the EV grant fund. SB21-260 raises the fee to $54 in 2023, growing to $146 by 2030, to adjust for inflation.

Enterprises

SB21-260 creates four enterprises, or government-owned businesses, two of which will aid M/HD ZEV integration: the clean fleet enterprise (ride-hailing and retail delivery fleets) and the public transit enterprise that. Funding will come from fees like the TNC fee, among others, as described in the *Tax Credits and Fees* section.

CEO EV Plan Tasks

RAQC to fund M/HD ZEVs for 20–25 fleets statewide through the ALT Fuels Colorado Program.

CEO to engage industry to develop future strategies and goals for medium and heavy-duty vehicle adoption beyond VW settlement funding.

CDOT to work to integrate recommendations from CEO's EV Equity Study into its transit electrification grant programs by January 2023.

Key Stakeholders

RAQC, CHPHE, and the Colorado Clean Energy Fund

Fund, the Highway Users Tax Fund, and the State Highway Fund, among others. As new funding becomes available, the state will apply it to projects outlined in the 10-year strategic plan. SB 21-260 creates three electrification enterprises - one focused on deploying EV charging and hydrogen fueling infrastructure, one on deploying ZEV transit buses, and one focused on fleets adoption of ZEVs, including school buses, M/HD fleets, TNC vehicles, and public fleets. Collectively, these are projected to invest approximately $730 million over the next decade; in addition, the Colorado Electric Vehicle Infrastructure Fund is projected to invest an additional $115 million in EV infrastructure over that time. The Nonattainment Area Air Pollution Mitigation Enterprise created by the legislation will help mitigate the environmental and health impacts of increased air pollution from motor vehicle emissions in Colorado's nonattainment areas resulting from the growth in TNC rides and retail deliveries.

Components

- **Develop policy objectives to help better align grant programs with zero emission transition needs**: Shape programs to focus less on a 1-for-1 replacement with diesel vehicles and more on easing ZEV adoption barriers.
- **Allocate funding across the M/HD sector to address unique needs**: Based on current model availability, transit and school buses have the most mature pool of ZEVs that are being deployed today. The Clean Transit Enterprise, approved in SB21-260, will support transit agencies on their path to achieving successful electrification. For other market segments, current commercial ZEV models are limited and generally produced by small start-up manufacturers. While major delivery companies like Amazon and FedEx are making significant strides in procuring electric delivery trucks, for smaller fleet operators who currently buy used vehicles, these vehicles are often cost prohibitive. While continuing to fund more mature markets, the state should consider targeting public funds—especially grant and incentive programs—towards sectors, populations, and locations that are not likely to be served by the private sector in the near term. For example, a portion of the limited public grant funding should be leveraged to support the more nascent trucking market providing technical support and lowering upfront costs for fleet operators. This sector will also be supported by the Clean Fleet Enterprise approved in SB21-260.
- **Develop policies that establish guarantees for end-of-life asset values – both for the vehicle and batteries**: Collaborate with markets that can utilize and benefit from the next life of the asset (e.g., second and third truck/bus owner, batteries as storage devices). One study by the Massachusetts Institute of Technology found that degraded EV batteries that are no longer fit for vehicle use could have a "useful and profitable" second-life for more than a decade as backup storage for utility-scale solar installations.[57] As such, many automakers are exploring pilots to test second-life viability and others are designing battery development from the start to make end-of-life repurposing as easy as possible.[58] The Colorado Energy Office is conducting a battery storage study in 2021. This study will examine the costs and benefits of battery storage in combination with direct-current fast-charging (DCFC) technology, develop a framework for legislative and utility policy recommendations and provide insight into a future pilot combining battery storage and DCFC.
- **Introduce flexibility for utilities to finance vehicles and infrastructure**: Where the private sector is unwilling or unable to invest, state entities should take action by utilizing existing innovative financing mechanisms like the Colorado Clean Energy Fund —the state's green bank— and by working with state regulators to evaluate the role of the utility in supporting customer ZEV adoption

through financing mechanisms like on-bill financing and vehicle to grid models, in addition to soft cost initiatives the utility may support (e.g., fleet advisory services).[xxiv]

Incentives

Incentive programs have been shown to stimulate markets by influencing consumer behavior by lowering costs to encourage procurement when markets are relatively new and technology is relatively expensive. While less information is known about the effectiveness of incentives for M/HD ZEV fleets, LD ZEV markets have been expanded by incentive programs.

Incentive programs often benefit "early adopters" looking to procure new vehicles but do not tend to benefit vehicle owners who purchase vehicles in secondary and tertiary markets, or operators who choose to lease vehicles. [xxv] Many M/HD vehicle owners fall within these two categories, which may limit the impact that incentives will have on encouraging M/HD ZEV deployment unless their needs are taken into account in designing incentive programs. Developing an effective structure and program size is also important. Incentive programs are often not large enough to meet existing demand. For example, currently the California Heavy-Duty Voucher Incentive Program (HVIP) program is oversubscribed and with a long waitlist (see *Vehicle Scrappage Programs – State- and City-Level Examples* call out box).

Components

- **Consider targeting public funds:** Grant and incentive programs should be targeted towards sectors, populations, and locations that are not likely to be served by the private sector in the near-term. Particular focus should be given to supporting smaller fleet operators where high upfront costs may be more prohibitive or fleets operating within low-income and disadvantaged communities that experience disproportionate impacts of vehicle-related emissions.

Ease of Implementation: Can be implemented at the city, state, public utilities commission, and federal level.

[xxiv] A larger discussion on the role that utilities can play in M/HD vehicle electrification in the *Complementary Utility Actions* section of this report.
[xxv] While incentive programs can be designed to allow leases, they often are not. Keeping these M/HD specific considerations in mind when developing programming to increase M/HD ZEV deployment will be important to ensuring that the specific needs of the market are being met.

Existing Federal Programs that Support ZEV Programs

Volkswagen Mitigation Fund (VW Fund): Colorado received over $68.7 million to invest in transportation projects out of a $14.9 billion total settlement.

EPA Diesel Emission Reduction Act (DERA): Federal funding to mitigate the health and environmental impacts of diesel emissions.

U.S. DOT Rebuilding American Infrastructure with Sustainability and Equity (RAISE): Federal funding for surface transportation capital projects. $1.0 billion made available in 2021.

U.S. DOT Infrastructure for Rebuilding America (INFRA): Transportation projects of national and regional significance that are in line with the Biden Administration's principles for national infrastructure projects that result in good-paying jobs, improve safety, apply transformative technology, and explicitly address climate change and racial equity. $889 million available nationwide in 2021.

American Recovery and Reinvestment Act of 2009 (ARRA): Federal stimulus funding passed in response to the Great Recession of 2008, including $6.1 billion for advanced vehicles and fuels.

U.S. DOT Congestion Mitigation and Air Quality Improvement (CMAQ) Program: Federal funding following the passage of the Clean Air Act Amendments of 1990 for surface transportation projects.

Clean Cities: Clean Cities carries out this mission through a network of nearly 100 coalitions – including Northern Colorado Clean Cities and the Denver Metro Clean Cities.

FTA – Buses and Bus Facilities Competitive Grant Program; Capital Investment Grants (CIG); Innovative Coordinated Access and Mobility Pilot Program (ICAM) – Mobility for All; Low or No Emission Grant Program: A series of FTA grant programs, typically for 5307 eligible transit agencies (e.g., fleets that have been selected as "designated participants" in the federal program 49 U.S.C. 5307 by their state Governor).

Federal Highway Administration (FHWA) Accelerated Innovation Deployment (AID) Demonstrations Program: Federal funding to accelerate the implementation and adoption of innovation in highway transportation. Currently dormant.

FHWA Nationally Significant Federal Lands and Tribal Projects (NSFLTP): Funding for the construction, reconstruction, and rehabilitation of nationally-significant projects within, adjacent to, or accessing Federal and tribal lands. Currently dormant.

Federal Lands Access Program (FLAP): Funding to improve transportation facilities that provide access to, are adjacent to, or are located within Federal lands. The program is currently closed in Colorado and anticipates a call for projects in 2024 with over $15.5 million available per fiscal year.

The following section provides more detailed examples of incentives including tax credits and fees, rebates, and voucher incentive programs.

Tax Credits and Fees

Tax credits are another mechanism to alleviate the high cost of ZEVs. Tax credits are designed to encourage adoption of a nascent technology and spur innovation. They are often developed with a declining incentive structure to lower the incentive as adoption rates grow and as the market becomes self-sustaining. There are a number of existing state and federal tax credits available to help purchase ZEVs, including Colorado's electric and plug-in hybrid electric vehicle tax credits available for purchase or lease of light-, medium-, and heavy-duty electric and plug-in hybrid electric vehicles.[59] Alternative models at the federal or state level could include creating an Investment Tax Credit or other type of credit for M/HD alternative fueled vehicles specifying a certain weight threshold.[60]

In the long-term, other mechanisms will need to continue to support an ever growing system; the Denver Regional Council of Governments found that vehicle miles traveled on Denver regional freeways and major roads could increase 43 percent by 2040.[61] As more consumers convert to ZEVs, states are grappling with how to make up for lost revenue from state gasoline taxes—which provide nearly 40 percent of transportation funds nationally.[62] Some states are implementing additional ZEV registration fees to fill this gap or utilize funds to build out ZEV infrastructure. Advocates for electric vehicle adoption believe that while EV drivers should contribute a registration fee towards road use, it should be lower than what drivers of ICE vehicles pay because (1) they do not pollute as much and (2) implementing the policy too early could curb the growth of a nascent technology.[63] In some states, the EV fee is more than double the annual average gas tax, like in Wyoming where it is 130 percent higher.[64] In Colorado, SB21-260 modified the state's prior fixed annual EV registration fee of $50 to a dynamic fee that adjusts yearly for inflation.

Complementary or alternative revenue sources to an EV fee could include charges for road usage applicable to all drivers who utilize Colorado's infrastructure (i.e., a road usage fee)—not exclusive to those who drive alternative fuel vehicles. Across the country, state and regional pilot programs are exploring fuel tax alternatives like VMT or mileage-based user fees (MBUF) utilizing funding from the Federal Surface Transportation System Funding Alternatives (STSFA) grant program.[65] While more traditional road usage charges (e.g., tolls) have not been commonplace in Colorado, tolled express lanes are being implemented on some corridors. The benefit of this type of policy is that it would apply to all vehicles and vehicle types and if desired, could target specific vehicle fleets more than others (e.g., vary by vehicle size and type). SB21-260 creates fees that target specific vehicle fleets like transportation network companies (TNC), taxis, retail delivery, rental vehicles, personal car sharing, or autonomous vehicles. These fees will fund Colorado's transportation enterprises including the Clean Fleet Enterprise (focused on ride-hailing and retail delivery fleets) and the Clean Transit Enterprise with revenue collection for the new fees beginning in FY 2022-23.[xxvi]

Components

- **Consider alternative fee structures that can be applied across vehicle types:** Alternative structures should adequately account for all drivers' impact on the transportation system (e.g., Colorado's new road usage fees that target specific fleets that have high VMT and road usage).

[xxvi] Colorado enterprise funds are a type of state-owned business authorized by the Colorado's Taxpayer's Bill of Rights (TABOR) whose revenues are not subject to the state's revenue cap. This allows the state to implement programs utilizing the revenue generated from the enterprises without cutting other programs to stay within a cap.

- **Evaluate a manageable timeline for implementing EV fees for M/HD vehicles**: Ensure that policies do not disincentivize shifting to alternative vehicles before the market becomes more mature. Colorado has accounted for this timeline in SB 21-260 by phasing in a road usage equalization registration fee on both regular and commercial EVs, growing from $4 in FY 2022-2023 to $96 in FY 2031-2032.

Ease of Implementation: Fees have already been legislated in Colorado through SB21-260, and electric and plug-in hybrid vehicle tax credits for M/HD vehicles are already available.

Rebates

Rebates also help bring down the price of new ZEVs and can be offered at or after the point of sale. Point-of-sale rebates reduce the purchase price of a vehicle at the point it is purchased as a "cash on the hood" deal. For other rebates, the benefit occurs as a return after the original upfront payment – a M/HD ZEV owner does not see a decreased upfront sticker price but rather sees the savings after the vehicle has been purchased and the rebate request has been submitted, processed, and granted. For some, this process may be difficult to navigate or dissuade them if they must wait to get money back, sometimes multiple months.

Components

- **Evaluate feasibility of a point-of-sale rebate:** Expand offerings to compliment current grant programs offered in Colorado that can decrease the amount that is necessary to finance the purchase of a ZEV. The Clean Fleet and Community Access enterprises created by SB 21-260 have the authority to develop rebate programs.

Ease of Implementation: Has been implemented at the state and federal level.

Funding Sources – Utility Examples

Funding for rebate programs can come from sources beyond local, state, and federal programs – utilities can serve as core partners for both vehicle conversion and infrastructure buildout.

For example, Portland General Electric's (PGE) Drive Change Fund awards millions of dollars to projects to help electrify transportation throughout the state.[66] Through Oregon's Clean Fuels Program, electric utilities are eligible to generate credits from their residential customers charging EVs. In turn, those credits are sold and used to fund activities that will increase the pace of transportation electrification. As a result, PGE awards grants that will specifically benefit underserved and vulnerable populations. Eligible project types include purchasing M/HD EVs as well as the charging infrastructure to support them. One of the 2021 recipients used the funding to purchase a Lion Electric Class 8 rear-loading refuse truck, along with DCFC and level 2 chargers to support the vehicle.

In Colorado, Xcel Energy's Transportation Electrification Plan includes up to $5 million in vehicle rebates for lower-income customers. The "Equity Rebate" provides an upfront $5,500 rebate for new personal EVs and $3,000 for used EVs under $50,000. The PUC requires that the rebate be used in place of the existing state EV tax credit. This program offers an opportunity for consumers who are not able to afford the upfront cost of a light-duty EV to be able to receive a reduced sticker price of the vehicle without needing to wait until after they file their taxes. Establishing new incentives like the Equity Rebate that reduce upfront costs at the time of purchase for M/HD vehicles could serve a similar purpose for small fleets that do not have the upfront capital to spend on more expensive alternative fuel M/HD vehicles.

Voucher Incentive Programs

Voucher incentive programs encourage faster fleet turnover by providing incentives for vehicle scrappage. Federally, the Consumer Assistance to Recycle and Save (CARS) program during the financial recession of 2008 led to the implementation of vehicle scrappage, or "cash for clunkers" programs across the country but, once the funding for this program was depleted, many of these programs disappeared. Many federal funding programs, as well as the VW Settlement program, include a scrap and replace requirement for provision of funding.

Scrappage programs can be an inefficient approach to reducing transportation emissions if not effectively designed and implemented, but can have major benefits for low-income communities and areas with significant air pollution challenges. Since being broadly implemented, studies have shown that vehicle scrappage programs are more effective in high polluting urban areas where the air pollution is more significant and therefore where air quality improvements could be higher (e.g., the Denver Metro / North Front Range Ozone non-attainment area). Additionally, urban areas are likely to have better access to other forms of transportation and other complementary policies (e.g., low emission zones) which have also been shown to increase program effectiveness.[67] In Colorado's grant programs, the scrap and replace component has been underutilized by smaller fleets that only own a few vehicles. These smaller fleets are risk averse and do not want to eliminate one of their ICE vehicles (which they know how to operate and maintain) for a new, more expensive ZEV that they have never used. It will be important to evaluate ways to modify existing vehicle scrappage programs to address these needs. For example, Colorado's VW Settlement transit grants allow agencies to hold onto the vehicle they are replacing for up to 12 months before scrapping it to let them build confidence that the ZEV can run their routes without any service disruptions. Another example could include providing a greater incentive to a smaller subset of small fleets that would otherwise not consider procuring a ZEV would be more effective when compared to a smaller incentive for more fleets that is not high enough to encourage vehicle retirement of the oldest and highest emitting vehicles.

Components

- **Appropriately structure vehicle scrappage programs:** A study conducted by the ICCT in 2015 found that effective vehicle scrappage programs deployed the following approaches:[68]
    - Replacement vehicles need to be as clean as possible (e.g., ZEVs), replacing older vehicles with vehicles that meet more stringent emission standards and have better fuel economy;
    - Program implementation, management, and enforcement should ensure expected benefits are actually achieved;
    - Fiscal incentives should be carefully tailored to optimize both environmental benefits and cost-effectiveness;
    - Program design should carefully consider and balance the different roles of national, regional, and local policy makers; and
    - Governments should consider implementing complementary fiscal policies with additional incentives such as low emission zones and regulatory backstops.

Vehicle Scrappage Programs – State- and City-Level Examples

A number of states have developed programs that incentivize vehicle scrappage utilizing a wide variety of funding sources and, in some cases, have chosen to provide increased incentives for vehicles located in areas that are disproportionately burdened by vehicle pollution.

Utilizing Regional Greenhouse Gas Emissions Funding—New Jersey's Zero Emissions Incentive Program (NJ ZIP), is allocating $15 million to support businesses and institutions in purchasing new, medium-duty (Class 2b-6) ZEVs that will operate in the greater Newark and Camden areas. Small businesses receive a $2,000 bonus per vehicle scrapped and replaced with a NJ ZIP Voucher-Funded ZEV.

Utilizing VW Settlement Funds—New York's Truck Voucher Incentive Program offers between $30,000 and $385,000 for fleets that purchase or lease BEV, Plug-in Hybrid-Electric Vehicle (PHEV), Fuel Cell Electric Vehicle (FCEV), hybrid, Compressed Natural Gas (CNG), or propane Class 3-8 vehicles and scrap a similar older diesel vehicle that is part of their fleet.

State Budget Funds—California's On-Road Heavy-Duty Voucher Incentive Program provides funding between $10,000 and $60,000 for fleets with 10 or fewer vehicles to replace older, more heavily polluting vehicles. The program is funded by the Carl Moyer Program, which receives funding from state legislation. Fleet owners that operate vehicles with 2009 or older model year diesel or alternative fuel engines may be eligible for funding towards the purchase of a replacement vehicle that has a 2013 or newer engine that is cleaner than the vehicle that is to be scrapped.

Road Pricing

Congestion pricing policies have the ability to significantly impact emissions and encourage alternative modes of transport within a region. Where congestion pricing policies have been applied, they have been shown to reduce use of personal vehicles within targeted zones and, when appropriately applied to all vehicles, have been shown to reduce congestion and emissions within regions and improve public health. Pricing schemes are typically initially met with local opposition though often receive higher approval once communities have more information or experience tangible benefits like decreased travel time.[69] While many programs have focused on passenger vehicles to date, some are beginning to consider how commercial vehicles would be considered in a congestion pricing policy. The Regional Plan Association has suggested it may be beneficial for some commercial vehicles to be exempt from congestion pricing as is done with some types of passenger cars, finding that doing so could "soften the impact on small business… [but small businesses] should continue to be incentivized to program trips as efficiently as possible."[70] The group concluded that further research is needed on the exemption of commercial vehicles from various proposed policies.

Relevant State Policies and Policies Under Consideration

Colorado's Existing Programs

HOV Lane Access

Colorado has previously permitted electric/gas hybrid vehicles to use highway Express Lanes – High Occupancy Vehicle (HOV) and High Occupancy Toll (HOT) lanes – with a single occupant. The exemption ended in May 2020.

Green Banks – Colorado Clean Energy Fund

Colorado worked with the U.S. Department of Energy and the Coalition for Green Capital to create the Colorado Clean Energy Fund, intended as a green bank for the state that could fund clean energy and energy efficiency investments, including EV and EV charging infrastructure.

CEO EV Plan Tasks

None

Key Stakeholders

CDOT, CEO, DRCOG, MPO, and State Legislature

Several studies show that zero emission zones and low emission zone policies (discussed in the *Zero and Low Emissions Zones* section) can lead to reduced air pollution but that the amount of the reduction varies from "no discernible effect to a reduction of 32 percent." The design and implementation of the policy impacts how effectively emissions are reduced.[71,72]

A few congestion pricing models are described below.

- **Cordon Pricing** is either a variable or fixed charge to drive within or into congested areas within a city. These prices may increase as the driver gets further into the center of the city and can change depending on the time of day. Often citizens that live within the city center are eligible for permits or vouchers that reduce the price for traveling into and out of the cordon zone so that they are not disproportionately burdened by the pricing policy.
- **Area Pricing** puts a per mile charge on all roads within an area that may change depending on the time of day or level of congestion.

In order for congestion pricing to be equitably applied to all socio-economic groups, access to other transportation options is essential. Studies have shown successful congestion pricing schemes: London, Singapore, and Stockholm had "an efficient public transportation system, compact development, walkability, and limitations on the use of private vehicles."[73] London, for example, saw large decreases in private vehicles and increases in public transit when it first implemented its cordon pricing scheme, but has since seen transit ridership plateau and decline with the rise of TNCs that are not included within the pricing scheme.[74] How congestion revenues are distributed significantly impacts how equitable the program is. Studies show that spending revenues on transit increases congestion pricing benefits to working-class families.[75] Providing passes for disadvantaged communities can also lessen the burden of the additional fees.

Emissions reductions vary based on size of city and price imposed, though most programs have seen a reduction in emissions. Stockholm, for example, has seen a 14 percent reduction in CO_2, seven percent reduction in NOx, and nine percent reduction in PM_{10} within the cordon zone compared to a 2.5 percent reduction of emissions outside of the zone since the program began.[76]

Components

- **Include communities in revenue usage decisions:** It is important to seek community feedback and buy-in when determining which programs and policies should be funded from the revenue generated by the road pricing policy.
- **Pair congestion pricing policies with increased transportation opportunities:** For service or delivery fleets, incorporating time of use components will be important to incentivize fleet operators to shift delivery times to time of day in which congestion is low and therefore idling times will be reduced.

Ease of Implementation: Approvals for road pricing policies can come from all levels of government but, where road pricing policies have been implemented, approval has typically come from state or national governments. Implementing this type of policy may require legislation or regulation. Congestion pricing applied to existing roads is highly controversial, and there has been very little uptake in the United States.

Zero and Low Emissions Zones

Zero emission zone (ZEZ) and low emission zone (LEZ) policies can have a large impact in high activity, high population density areas where emissions exposure is very significant and poses a threat to human health (e.g. city centers, ports, dense residential areas, etc.). These policies have already been deployed in over 250 cities.[77] The impact of the policies depends heavily on how it is implemented, with some studies showing limited emissions reductions if the zone is too small or not implemented in tandem with other policies that support disadvantaged communities and limit emissions leakage out of the low-or zero emissions zone.[78]

Studies note that LEZ policies are not as effective without greater access to affordable, attractive, and convenient transportation alternatives.[79] Additional policies (e.g., increasing public transport options, providing exemptions for residents living within the zone, supporting pricing schemes that support low-income households) should be implemented in combination with LEZ to ensure that ZEZ and LEZ policies do not disproportionately burden low income communities, small businesses, and residents who live within a LEZ or ZEZ. It is critical that low-income residents/businesses have a say in determining which equity policies are combined with the ZEZ and LEZ (e.g., low-income exemptions, revenue invested in EV fleet conversion, etc.). Additionally, cities should consider equitable forms of implementation and enforcement by allowing communities to be part of the implementation process in order to avoid inequitable and potentially harmful enforcement practices that could lead to over policing or hyper-surveillance of people of color. It is important to monitor the impacts of the policy both within and outside the ZEZ and LEZ as people in adjacent areas may realize an increased impact from LEZ.

Several cities have gone through a phased approach where policies become increasingly restrictive over time.[80] Studies note that in order for LEZ or ZEZ to effectively reduce emissions, especially in freight, national and local policies need to be aligned in order to send a signal to fleet operators to encourage fleet replacement plans.[81]

Components:

- **Develop complementary policies or program exemptions for small businesses**: Policies should ensure that they are not disproportionately burdening community members or businesses that exist within a LEZ or a ZEZ.[82]
- **Collectively decide on how revenue generated by ZEZ or LEZ standards should be used:** Participatory budgeting or other mechanisms can allow community members to determine transportation investment needs.

Ease of Implementation: ZEZ and LEZ policies have been implemented directly by cities and have also been implemented as part of a national policy.[83] Within the U.S., local powers have less authority especially if a ZEZ does not conform to a specific boundary. In the U.S., LEZs can be preempted by federal law, so would need to be structured carefully.[xxvii]

Additional Financing Solutions for M/HD ZEVs

While each of the above strategies can incentivize and support M/HD ZEV deployment, additional support will be needed to spur increased growth in the ZEV market. While public grant programs have and will continue to be important factors in lowering the upfront cost of M/HD ZEVs, public actors can provide additional support by using public funding to draw in private funding streams—making public dollars go further and enabling more consistent funding that is not tied to a singular source. Increased financing options coupled with additional non-financial support mechanisms discussed throughout this section can de-risk the transition to M/HD ZEVs, making it easier for fleet operators and other key stakeholders to begin to transition their fleets.

To support the ZEV market transition and to enable that market to reach the scale needed, providers of public finance and fleets should draw widely from a variety of financing approaches, targeting solutions that meet specific vehicle sector and use case requirements. The following approaches can be supported through both public and private entities and highlight several emerging approaches to financing the transition to M/HD ZEVs.

- **Leasing Models** have already been deployed, including vehicle leasing, battery leasing, and lease-to-own models. Leasing can lower the upfront cost of the vehicle and can make procuring vehicles less risky from an operation and maintenance viewpoint for fleet operators. While some fleet operators (e.g., trucking fleets) are used to leasing vehicles, leasing is not used as frequently with other M/HD fleets (e.g., transit fleets); some OEM manufacturers, like Proterra, have started to implement battery and vehicle leasing options for their bus fleet clients. In certain circumstances, existing grant programs may require vehicle ownership for participation. Increasing flexibility to enable lessee participation in grant programs may provide additional financing opportunities for fleet operators.
- **Green Banks** have been developed across the country to facilitate private investment in low carbon, climate-resilient infrastructure. The Connecticut Green Bank found that for every $1 of public funds

[xxvii] Depending on how a LEZ law is written at the state and local level, it can be preempted by three federal statutes: 1) the Clean Air Act; 2) the Energy and Policy and Conservation Act; or 3) the Federal Aviation Administration Authorization Act. For more information on the policy implications of preemption see https://climate.law.columbia.edu/sites/default/files/content/docs/Legal%20Tools%20for%20Achieving%20Low%20Traffic%20Zones.10329.pdf.

committed by the Green Bank, an additional $6 in private investment resulted.[84] For many years, green banks have been used to primarily finance renewable energy deployment and energy efficiency upgrades. More recently, several have begun exploring financing models to support transitioning M/HD vehicles to ZEVs. Example programs include investing in EV production and/or charging infrastructure, financing EV fleet leasing or purchasing, or financing EV battery leasing. In 2018, Colorado created a green bank— the Colorado Clean Energy Fund. To date, the fund has developed its strategy, products, and business model and received $30 million in funding from SB21-230 to deploy towards transportation programming.

- **Vehicle to Grid (V2G)** projects offer the potential for an additional revenue stream for fleet operators by allowing either the fuel cell vehicle or the battery electric vehicle to communicate with the power grid to sell demand response services to the utility. School bus fleets in particular have shown increasing interest in V2G projects due to their long idle periods during the middle of the day and, more importantly, their potential to serve almost exclusively as a battery during summer months when school is not in session. Several utilities across the country have deployed pilot programs with school bus fleet operators to evaluate the effectiveness of V2G programs (see *Utility Vehicle to Grid Projects* call out box).

Utility Vehicle to Grid Projects

Utilities across the country have begun developing vehicle-to-grid (V2G) pilot demonstrations with school bus fleets. Both entities—the school bus fleet operators and the utility—can benefit from V2G projects: the utility is able to utilize vehicle batteries during peak energy use periods or during outages and the fleet operator is able to generate additional revenue from a vehicle when it is not in use. Two pilot programs are shown below.

- **Con Edison and White Plains School District**: In 2018, Con Edison partnered with Lion School Buses and the White Plains School District to implement a V2G demonstration project in White Plains, New York. The project includes five Lion School Buses that will transmit energy from the School District back to the grid. The project will allow stakeholders to test the economic viability of V2G to determine if the concept should be implemented in other areas to increase resiliency and to reduce electric vehicle costs. National Express, Con Edison, and the New York Energy Research and Development Authority funded the project.
- **SDG&E School Bus Pilot**: In 2019, San Diego Gas and Electric received $1.7 million for a V2G pilot program that will allow the utility to connect 10 electrified buses to California ISO's energy market. Like Con Edison's pilot, the project is meant to test the viability of V2G for school bus fleets to determine how beneficial they could be to fleet operators and utilities.

- **Pay-As-You-Save (PAYS) Model** enables utilities to pay upfront capital costs and be reimbursed over time by the fleet operator through on-bill financing. M/HD vehicle electrification has parallels to existing energy efficiency programs (e.g., rooftop solar) in terms of large up-front capital costs and long payoff periods. The PAYS model has proven effective for energy efficiency and can be deployed in a similar way within the transportation sector; it is now being actively explored in cities and states across the U.S., including Arizona and North Carolina.

- **Transport Energy Service Company (T-ESCo) Models** split responsibility between the operator, procurement company, government, and infrastructure company. In this model the T-ESCo purchases the equipment or infrastructure for fueling the vehicle. This reduces the risk to the operator by lowering infrastructure costs and spreading those costs across multiple fleets. The operator pays the T-ESCo back over time with the operational savings they accrue. While this type of model has been deployed with CNG transit buses it has not been used for M/HD ZEVs, though it is possible that a similar model could be deployed for FCEVs or EVs.

Components

- **Support the development of pilot programming:** Many of these policies would need to be tested and possibly subsidized using public funds.
- **Encourage and implement public-private partnerships and collaborations:** State entities should work to increase engagement with the private sector on ways to increase funding opportunities to scale ZEV deployment.

Ease of Implementation: The implementation of each of these programs will vary and may require legislative or regulatory approval. Each of these programs and policies will likely require strong public-private partnerships that can be supported by state entities.

Procurement Provisions

Procurement provisions from large fleet owners, like companies or governments, can provide a market signal to OEMs to increase production of ZEVs. State governments could also set targets for fueling infrastructure for M/HD vehicles by requiring that all new distribution facilities are served by a certain percentage of EVs.[xxviii]

An EV's emissions footprint is dependent on the grid it charges from. As the share of U.S. electricity from coal power decreases and the share from renewable energy resources increases, the emissions benefits of driving an EV grows: EVs are the only commercially available vehicle that gets cleaner over time as the grid decarbonizes. M/HD vehicles have greater vehicle emissions (PM, CO_2, and NOx) than LDVs, making ZEV conversion critical to reducing emissions and improving air quality in disadvantaged communities. Sector-specific incentives or targets to encourage vehicle procurement or charging infrastructure development

Relevant State Policies and Policies Under Consideration

Colorado's Existing Programs

ZEV Targets

In 2019, Governor Polis set goal of 940,000 light-duty EVs in the state by 2030 (EO B 2019 002).

In July 2020, Governor Polis signed the Multi-State Zero Emission M/HD Vehicle Memorandum of Understanding, which sets a goal to work towards making all new sales of M/HD vehicles ZEV by 2050 at the latest.

City and County Targets and Collaboratives

Colorado's GoEV City Coalition is made up of six cities and counties across the state that commit to creating an EV Action Plan within 18 months of joining.

In its 80x50 climate plan, Denver has a goal of reaching 100 percent carbon free public transit by 2050.

Eight communities and counties within the state are part of the Climate Mayors Electric Vehicle Purchasing Collaborative, which works to leverage the buying power of city governments to reduce the cost of EVs – including school buses and medium- and heavy-duty chassis – and charging infrastructure.

Various Colorado cities have committed to ZEV procurement targets. For example, Boulder and Vail aim to transition their bus fleet to clean energy fleets by 2030 and 2032, respectively.

SmartWay

The Colorado Motor Carriers Association is an existing partner of EPA's SmartWay program.

CEO EV Plan Tasks

RAQC—with the support of CDPHE, CDOT and CEO, and in collaboration with other interested agencies and stakeholders—to develop strategies to support adoption of ZEV school buses.

CDOT, RAQC and CEO to work with transit agencies, electric utilities, and other stakeholders by July 2021 to establish timelines, identify strategies, and dedicate sufficient resources for the conversion of the state transit fleet to 100 percent ZEVs no later than 2050, with an interim target of at least 1,000 transit ZEVs by 2030. This includes investigating the adoption of a Clean Transit Rule, an equity and rural-focused transit option, and a state-approved master purchasing contract for EV procurement.

CEO and CDOT will examine strategies for third-party financing on the incremental capital costs of electric buses through mechanisms including battery leases, utility on bill financing, and other mechanisms.

Key Stakeholders

RAQC, CDPHE, CDOT, CEO

[xxviii] Most states have not yet set charging infrastructure-specific goals, targets or mandates. Most recently, however, the California Energy Commission (CEC) released a study that evaluates the charging infrastructure needed to meet Governor Newsom's September 2020 Executive Order that establishes the goal of 100 percent ZEV operations for M/HD vehicles where feasible by 2045. The CEC's modeling found that 157,000 chargers are needed to support 180,000 M/HD ZEVs. The report can be found at https://efiling.energy.ca.gov/GetDocument.aspx?tn=238032.

have the potential to encourage increased deployment of low- and zero-emission vehicles.

Components

- **Effectively communicate with fleets:** Educate fleet operators on the tax credits, rebates, and other grants and programs that are available to them within the state —including programming that is not offered by the state but by another entity (e.g., utilities).
- **Convene appropriate stakeholders**: The state should support a dialogue with fleet operators and other stakeholders to help better understand what the major barriers to implementation are from their perspective so that policies and programs can be developed that meet those needs. This could include fueling providers, utilities, overburdened communities where there is high M/HD fleet traffic, and fleets across the state.

Ease of Implementation: Cities and states can set fleet procurement targets for their own fleets and can encourage fleets to transition to ZEV through incentive programs.

Public Procurement Policies

One way that states and localities can accelerate the ZEV transition is working with their state agencies and fleets to set procurement targets and lead by example. At the federal level, President Biden issued Executive Order 14008, *Tackling the Climate Crisis at Home and Abroad*, in which he directs Federal (which includes 645,000 cars and trucks), State, local, and Tribal agencies to procure carbon-free electricity and clean, zero-emission vehicles.[85] While today the supply of M/HD ZEVs is limited, fleet commitments like these send a market signal that the demand is rising. This can also be impactful at the local level, particularly with transit agencies that already have access to multiple models of transit ZEVs. For example, the California Air Resources Board requires that California transit bus fleets must be zero-emission by 2040; to reach that goal, all new transit bus purchases must be ZEVs (battery electric vehicle [BEV] or FCEVs) starting in 2029.[86]

Ease of Implementation: Some vehicle classes – transit and school buses – are better able to convert today while higher conversion rates of other M/HD vehicles will become more feasible as the market advances. Some vehicles, like emergency vehicles, will be harder to convert and are often exempted from public fleet procurement policies.

Private Procurement Policies

Private fleet ZEV procurement policies have the potential to markedly transform the M/HD market. Although fleet vehicles in the U.S. comprise only 3 percent of all registered vehicles, they have the potential to have an "outsized influence" with their ability to "drive scale," ultimately reducing the cost of vehicle technology and infrastructure.[87] This market power is illustrated through the success of collective campaigns like EV 100, through which over 100 member companies have deployed 169,000 EVs to date and committed to electrifying 4.8 million vehicles globally by 2030.[xxix,88] California is currently in the process of designing fleet ZEV procurement rules that would apply to government, drayage, and large private fleets, knowns as the Advanced Clean Fleets rules.

Fleet conversion of M/HD vehicles also has equity benefits. It is often the case that depots, warehouse districts, and highways are located in or near communities that disproportionally bear the effects of air pollution. Similarly, local community groups in Colorado have advocated for the replacement of diesel school buses that can heavily impact the risk of respiratory illnesses like asthma in children.[89] By supporting

[xxix] See Appendix III for a sample of fleet commitments and procurements.

the private fleet ZEV transition, Colorado can help improve local air quality, especially for overburdened, frontline communities.

Ease of Implementation: The State can support fleets through incentives, rebates and tax credits. Fleets will also need implementation and advisory support described in other sections of this report.

Private Procurement Commitments

Ridesharing app Lyft has committed to reaching 100 percent EVs on its platform by 2030. In the announcement of this long-term vision, Lyft referenced Colorado's support in expanding the state tax incentives to their Express Drive (Lyft's program that allows drivers to drive and earn with a rented vehicle in 35 cities) partners' vehicles. In launching the program in Colorado, Lyft's Sustainability Team engaged with Colorado policy makers to make 200 vehicles available to drivers. While this program focused on LDVs, it illustrates a model of collaboration between private fleets and the state. It can serve as a model for how larger private fleets can work with state policymakers to outline the policies and practices that would best facilitate a conversion to ZEV vehicles.

Curb Management

Curb management policies encourage more efficient road usage by encouraging vehicle usage patterns that reduce congestion and idling for M/HD fleets thereby reducing emissions from the M/HD vehicle sector.

Emission reductions vary depending on the type of curb management practice that is implemented. While curb management policies generally limit personal vehicles, policies can lead to an increase in TNC use instead of transit use which may limit its impact on emissions. Curb management should be implemented in combination with increased public transportation opportunities.[90] Creating shared mobility zones that have varied usage throughout the day (e.g., freight loading overnight, TNC drop-off zone during commuting hours and transit & parklet space during the day), can reduce congestion thereby reducing emissions.[91]

Curb space management policies (e.g., converting traditional parking spaces into bus lanes, bikeways, freight loading, public spaces, etc.) can decrease congestion, improve mobility, and enhance equitable use of space if effectively implemented and managed considering the specific needs of a given location.[92] Effective monitoring of local street and curb usage is essential to the effective implementation of curb space management. The rise of TNCs and e-commerce have made curb space management policies even more essential to reducing congestion and emissions within urban centers.[93] Curb management policies, especially in dense urban settings, often benefit more citizens than are hindered by the lack of parking. It is critical that low-income residents/businesses have a say in determining which equity policies are implemented (e.g., extend gate times at ports; tailor delivery times in residential areas to control noise, traffic).

Components:

- **Engage with local communities:** Curb space management policies are hyper local and require significant engagement with communities to describe the local benefits of changing parking policies to encourage behavioral shifts in land use management.

Ease of Implementation: Curb space management is determined and approved by city and county planning offices and does not require state or national interventions though funding can come from those sources. As part of Colorado's COVID-19 Recovery Plan, the state legislature allocated $30 million to the Revitalizing Main Streets Program to support local communities as they find innovative ways to reuse public spaces and help businesses reopen safely.[94] This effort is intended to help communities across the state implement transportation-related projects that improve safety and yield long-term benefits to community main streets.

The City of Seattle has implemented "Flex Zones" throughout the city that serve different functions (e.g., mobility, access for people, access for commerce, activation, greening, storage) depending on the location.[94]

Land Use and Planning

Urban planning plays a key role in reducing transportation emissions. Developing land use policies that prioritize mixed-use, compact development that favors active transportation and public transportation and make use of existing or poorly used land within developed areas, has the potential to dramatically reduce VMT by shifting design priorities away from single occupancy vehicles in favor of public transit, improving air quality and public health in addition to reducing GHGs.[96]

Transit infrastructure investments can include a myriad of components, including bus rapid transit lines (with limited stops and dedicated lanes) and integrating bus services with metro or rail offerings, encouraging transportation mode shifting into public transportation. Some studies have shown that VMT can be reduced by transit-oriented development (TOD) by 20-30 percent compared to more typical development.[97] A study produced by C40 found that urban land use and transportation planning could decrease emissions by 3.7 Gt CO_2e annually from a reference scenario in 2030 rising to 8 Gt CO_2e in 2050 with the greatest reductions from deep improvements in residential building energy efficiency and from a transition to efficient public transport for urban mobility.[98] Importantly, planning and zoning that prioritizes mixed use development has been shown to strengthen local economies by reducing commuting time and by creating local jobs.[99]

Relevant State Policies and Policies Under Consideration

Colorado's Existing Policies

Regional and Local Corridor Planning

In December 2019, Governor Polis reaffirmed Colorado's participation in the Regional Electric Vehicle (REV) West initiative by signing a new REV West MOU which updates the MOU signed by the state in October 2017.

Since 2016, the FHWA has awarded EV charging, compressed natural gas, liquid natural gas, propane, and hydrogen designations for Colorado's I-25, I-70, I-76 corridors as part of its Fixing America's Surface Transportation (FAST) Act. In addition, Colorado US 285, US 50 and portions of US 160 and US 40 have EV corridor designations.

While both cater to light-duty ZEVs, similar models could be leveraged for M/HD ZEV deployment and coordination.

CEO EV Plan Tasks

None

Key Stakeholders

CDOT, CDOT, RTD, DRCOG. MPO, State Legislature

Regional and local transportation planning, like other planning processes, requires extensive community stakeholder input prior to plan approval. Historically, planning processes, including transportation planning policies, have not been equitable and have often prioritized affluent community needs over the priorities of low-income communities.[100] This has led to the development of less compact and more expensive development that does not favor affordability and does not prioritize public transportation. The regional and local transportation planning approaches described within this section place a priority on community engagement in addition to placing a priority on compact mixed-use developments that lessen individual vehicle use and enable shorter vehicle trips for delivery services. More traditional forms of planning put the onus on the planner to ensure that equity is considered within the process whereas planning approaches like TOD, complete streets, and smart growth create frameworks that place equity more in the center of the discussion. Equity should be built into these long-term planning documents to ensure that plan implementation focuses on equity. One of the goals of flexible mobility planning is to increase the equitable deployment of investments and policy interventions to prioritize the mobility needs of low-income individuals of color and address the historical neglect that they have experienced through more traditional zoning and permitting practices.[101] These considerations need to be implemented into planning processes and solidified in zoning plans in order to create more equitable land-use planning processes.

Components

- **Ensure sustained engagement of leaders in disproportionately impacted communities at every stage of the planning process:** This can help ensure that the process: 1) includes comprehensive, insightful documentation of existing conditions; 2) considers socioeconomic and health conditions and develops strong partnerships between public health and planning; and, 3) measures projected health impacts of scenarios.[102] Colorado is developing best practices for meaningful engagement, including drafting a climate equity framework and an EV equity study that is meant to provide a menu of options that the state can use to build equity considerations into the GHG reduction rulemaking process. Additionally, after being signed into law in July 2021 by Governor Polis, HB 1266 will create a new EJ ombudsman role by February 2022 who will report to the director of CDPHE as well as an advisory board within the Department.

Regional and Local Corridor Planning

Regional and local transportation planning create meaningful long-term plans that can incentivize long-term growth patterns of compact, mixed used planning which reduce VMT for single occupancy LDVs and M/HD delivery fleets alike. Decreased numbers of single occupancy LDVs also have the benefit of decreasing congestion within urban areas leading to more efficient drive times for medium-duty delivery fleets. Transit Oriented Development and Regional Transportation Planning are both examples of effective regional and local transportation planning.

- **Transit oriented development** is a planning approach that aims to establish mixed use, walkable and transit-oriented communities built through community consensus. When effectively implemented, TOD plans can increase economic development, lower housing and transportation costs, improve environmental and public health, create placemaking and community building opportunities, and improve transportation system performance and increase transportation choice.
- **Regional planning documents**, either done through councils of governments, counties, or regional transportation planning organizations, provide longer term visions for urban and suburban planning. These regional plans have the opportunity to create effective and lower emitting transportation options at a regional scale which is critical to ensuring city transportation policies fit into a larger regional planning process. As increased numbers of M/HD fleets begin to transition to ZEVs, regional planning processes will become increasingly important as planners and other key stakeholders, like utilities, will need to evaluate charging and fueling infrastructure locations.
- **Flexible mobility planning** takes a more dynamic view to land-use planning and zoning by implementing form-based codes (which allow communities to think beyond single-use zones to develop areas that can be used for multiple purposes but still fit into the existing “fabric” of the community), pink zones (areas where permitting and zoning rules are relaxed to spur small scale development) and by utilizing tactical urbanism (using short term and low cost methods to change street uses to test future planning approaches before investing heavily in changing existing infrastructure) to develop urban spaces that are fluid to make better use of public spaces, including roads and curbs, to enable more effective use of space by changing the use depending on the time of day with the goal of creating more inclusive spaces that reduce emission and improve public health.

Ease of Implementation: Regional and local planning is often facilitated by regional transportation organizations, councils of governments, or city or state planning organizations. While project funding is often supported by federal and state governments, local planners have authority over many of the local land use and zoning decisions. Because vehicles are likely to travel from one community to the next, coordination is required between multiple jurisdictions for meaningful transportation planning to occur. Flexible mobility policies are often implemented on a temporary basis and can be easier to implement.

Zoning and Permitting

Similar to the planning discussions above, comprehensive zoning plans can incentivize sustainable growth and can encourage behavioral shifts and decrease VMT — incentivizing the use of both light-duty and medium-duty ZEV delivery fleets within urban areas. Several examples are outlined below.

- Requiring new buildings to have EV-Ready parking spaces by incorporating EV infrastructure into building code requirements for new developments. Building infrastructure at the onset of a project can bring down charger installation costs significantly compared to building retrofits.[103]
- Promoting transit-oriented development that will lead to a greater use of state and local buses that are already in the process of electrifying.
- Including effective curbside and parking strategies that enable better use of the street (e.g., by creating fluid parking usage options for logistics firms, transit operators, TNC drivers in addition to pedestrian and bicycle users that fluctuate depending on the time of day).

Ease of Implementation: In Colorado, local buy-in and action at the individual municipality and county-level will be essential. Zoning rules are often most effectively implemented when permitting policies are streamlined and standardized to enable faster implementation. Without action at the local -level, it could be difficult for the state to pursue zoning and permitting strategies under current laws.

City-Level Examples of Zoning Policies

A number of cities have implemented thoughtful zoning policies—examples include the development of location efficient zoning that encourages compact mixed-use communities that improve overall efficiency within the transportation system; removing parking minimums (e.g., San Francisco); removing bans on multifamily housing to create denser, more walkable city development (e.g., Minneapolis); developing more pedestrian focused zoning; developing context specific standards based on community usage needs (e.g., Portland); and, offering developers density bonuses for building in close proximity to public transportation (e.g., Los Angeles, New York City).

Infrastructure Development

Policies that target or incentivize the development of charging infrastructure, in particular DCFC infrastructure, will be critical to ensuring that adequate and cost-effective charging opportunities are available for fleet owners.

State leadership can play a key role in developing a space where stakeholders can gather to share perspectives and expertise on what will be required for different fleets and locations to electrify. While there are commonalities across states and regions, when actual infrastructure is beginning to be installed and as vehicle deployments scale, state leaders will need detailed and forward-looking electrification planning processes that consider the rollout of various vehicle types and where they are likely to charge or be refueled.

Having a better understanding of how many fleet operators are planning to electrify and the timeline for that ZEV deployment can allow utilities to make the necessary electric grid upgrades and provide an opportunity for zero-emissions fuel providers to develop a strategy to ensure customer goals are met. By understanding how large the fleet is, what type of vehicles make up the fleet, and what the procurement timeline is will allow utilities and other key stakeholders to make more informed infrastructure planning decisions that look beyond the first installment of vehicles and into the second and third. This advance planning process can enable the state to make infrastructure buildout decisions that anticipate future vehicle deployment, thereby potentially reducing infrastructure costs associated with returning to a location to upgrade substations or re-dredge a parking lot to accommodate for the increase in vehicles.

Relevant State Programs and Programs Under Consideration

Colorado's Existing Programs

Grant Funding Opportunities

Charge Ahead Colorado: Provides financial support for EVs and charging stations.

ALT Fuels Colorado: Incentivizes the replacement and scrappage of pre-2009 Class 4-8 vehicles with alternative fuel vehicles. Additional funding may be available for associated electric vehicle charging stations if the vehicle or piece of equipment being purchased is electric.

CDOT Grant Programs: In 2019 CDOT offered two transit-oriented grant programs through VW funding that included infrastructure elements: a transit bus replacement program and a capital transit project, each of which included up to $100,000 for charging infrastructure.

CEO EV Plan Tasks

Set goal to develop an EV infrastructure goal by undertaking a gap analysis to identify the type and number of charging stations needed across the state to meet 2030 light-duty and M/HD vehicle goals.

Key Stakeholders

Utilities, PUCs, CEO, OEMs, fleet operators

It is likely that many operators will convert their fleet slowly over time. Especially in the early stages of vehicle electrification this will mean that the number of electric vehicles and the associated vehicle infrastructure needs could be low. Not planning for future electrification could lead a utility to modularly add on capacity upgrades for a particular customer— increasing cost and creating additional hurdles for infrastructure development over the long term.

Without clear plans and policies from the state that address customer concerns (e.g., range anxiety, infrastructure expense, and consistency in "fuel" prices across service territories and regions), vehicle owners may find the proposition of procuring a zero emissions fleet too risky, leading them to decide to delay conversion. This delay represents not only a delay in that specific fleet operator's electrification goals but also represents a larger delay in electric vehicle procurement. The goals and sales targets developed by the MOU states have set an aggressive timeline for M/HD vehicles electrification. In order to meet these aggressive goals, states will need to reduce risk and uncertainty in the market—for fleet operators as well as utilities. Addressing uncertainty for these two stakeholders is key —fleet operators, utilities, and their regulatory bodies need to feel confident that their infrastructure developments are providing meaningful long-term investments to their customer base. By supporting a long-term planning process that includes the thoughts and insights of OEMs, large fleet operators, coalitions of small fleet operators (e.g., trucking associations), logistics hubs, utilities, private infrastructure providers, government agencies, and community advocates, state leadership can begin to develop an electrification pathway that includes the differing needs of multiple stakeholders.

Components

The state can play a key role in convening stakeholders in the development of M/HD ZEV infrastructure by:

- **Increasing coordination across M/HD vehicle stakeholders**: State entities should work with utilities, fleet operators and OEMs to ensure coordinated infrastructure buildout. Organizations such as the Colorado Freight Advisory Council and Electric Vehicle Coalition should continue to play a role in providing invaluable advisory services and feedback.
- **Establishing long term infrastructure build-out plans**: Utilities can provide essential insights about grid expansion costs and time requirements in addition to providing unique insight into how to prepare for shifting electricity use cases. As will be discussed more in the utility section of this report, allowing utilities to build out some infrastructure upgrades that will be required for future infrastructure buildout during the initial construction of the charging site could create a more organized and planned approach to electrification.
- **Leveraging expertise of key stakeholders**: Providing a space for utilities, fleet operators, state entities, and vehicle manufacturers to share their distinct and critical expertise will be essential to ensuring that infrastructure buildout is coordinated and plans are factoring in all critical information.

Creating a Multi-Jurisdictional Partnership to Evaluate Infrastructure Needs and Potential Constraints: West Coast Clean Transit Corridor Initiative

The West Coast Clean Transit Corridor Initiative provides one example of regional collaboration to develop a roadmap to create a transportation corridor along the I-5 highway in Washington, Oregon, and California. The study was produced by a coalition of nine electric utilities and two agencies representing more than two dozen municipal utilities who researched vehicle, battery, and charging station technologies in addition to evaluating truck traffic to forecast EV truck populations and determine the number and size of highway charging sites.[104] The final report offers a proposed map of charging facilities along the I-5 and arterial highways in all three states. This study represents an important first step in establishing lines of communication amongst key stakeholders and also in highlighting key issues that will need to be addressed as charging networks are built out across service territories and states. Notably, the study found that developing charging locations in rural locations will be difficult and costly. These types of studies can allow utilities and other stakeholders to begin to map out not only the infrastructure that will be required but also the cost of the infrastructure build-out.

Market-Based Policies

State led standards and regulations can drive the uptake of M/HD ZEVs by providing clear targets and requirements that OEMs, fleet managers, and other critical stakeholders must meet in order to operate within a given state or region.

Market based approaches, unlike others described above, create mechanisms by which compliance entities must meet a certain emissions cap using a wide variety of approaches—either meeting a certain emissions reduction profile or paying for additional allowances that were not utilized by another party through an auction to cover the excess emissions. These requirements vary by implemented policy. This compliance flexibility creates cost-effective control strategies that establish a market wherein additional policies can be stacked to create further cost reductions. Often these additional programs (e.g., incentives, grants and loans, educational programming) can be funded directly from the revenue generated from the auction proceeds.

> Relevant State Policies and Policies Under Consideration
>
> ### Colorado's Existing Policies
>
> None
>
> ### CEO EV Plan Tasks
>
> None
>
> ### Key Stakeholders
>
> Executive Office, State Legislature, CDPHE, CEO

For all of these reasons, market-based approaches have been utilized for decades across a wide variety of sectors, with many states implementing standards and cap-and-invest policies within the power sector and, more recently, within the transportation sector. Market-based policies have been criticized for placing a disproportionate burden on low-income individuals and for not requiring localized emissions reductions within communities that are disproportionately burdened by poor air quality. When implementing new market-based policies that focus on reducing transportation emissions, it is critical that disadvantaged communities are at the center of program development both as key stakeholders and advisors and also as recipients of programs developed utilizing revenue proceeds.

To enable the effective implementation of market-based policies, the following elements should be considered. Additional policy specific components are outlined within the following sections.

- **Clear point of compliance**: Prevent emissions leakage (both into surrounding jurisdictions and into other portions of the lifecycle of the fuel) by including mechanisms to verify and ensure that the market is reaching desired goals and policy outcomes.
- **Independent verification**: An independent verifier should ensure that compliance is met through a reduction in emissions or that a fee is paid.
- **Stability mechanism**: Stability mechanisms should be implemented to prevent market volatility while still ensuring that emissions reduction goals are met. For example, many cap-and-invest policies have included cost containment reserves, emissions containment reserves, and minimum reserve price floors to ensure that prices and emissions never exceed a certain amount nor fall below a certain amount.
- **Set varying compliance obligations over time:** Consider back-loading compliance obligations to allow time for market participants to develop low carbon alternatives and adjust existing business models to meet new compliance obligations. The excess credits developed during the early years of the program should be allowed to be banked for use in later, more stringent years.

- **Utilize program proceeds to create complementary policies and initiatives:** Revenues can be utilized to achieve even greater emissions reductions or can be implemented to pursue other policy goals that will create a more robust transportation sector. This can include policies directed at achieving emission and air pollution reductions within disadvantaged communities.
- **Create dedicated funding to support low-income and environmental justice communities**: A portion of program proceeds should be dedicated to supporting programming designed to support low-income, disadvantaged, and environmental justice communities. These programs should be developed in partnership with these communities.

Cap and Invest Policies

Cap-and-invest policies set an overall declining cap on emissions from a defined group of sources and gases. The program creates an "allowance" for every ton of emissions allowed under the cap, and compliance entities—those producing emissions covered by the cap—must use allowances for every ton of emissions released. Compliance entities may use allowances to demonstrate compliance, trade them with other regulated sources, or bank them for future use. An allowance price emerges from the sale and trade of allowances; this price signal then guides compliance and investment behavior.

Within cap-and-invest policies, the majority of the proceeds developed from program actions are invested back into programs that support greater emissions reductions within the targeted sector. A number of states and regions have implemented cap and invest policies and since implementation have provided a significant source of revenue that has been distributed into programs that have increased efficiency and reduced emissions. For example, some programs, like California's cap-and-trade market, cover economy-wide emissions that include transportation emissions while others, like the proposed Transportation and Climate Initiative Program (TCI-P), will rely on a cap-and-invest system that specifically addresses emissions from the transportation sector (see Example Policies and Programs call out box).

The Polis administration has adopted a sector-based approach to GHG reduction that does not incorporate cap and invest or cap and trade programs, due to concerns about their complexity, their potential to exacerbate environmental injustice, and their political divisiveness, as seen in the long timeline and lack of progress in implementing TCI in the northeastern states. Thus, while this report includes these policies for completeness, this is unlikely to be a component of Colorado's policy approach.

Components

- Regulators should ensure that complementary policies and programs are creating meaningful transportation alternatives and are improving health outcomes for disadvantaged and environmental justice communities: Critical to that process is identifying community priorities and goals. State entities will need to engage with community leaders and stakeholders early and often in the process. This will help ensure that policies evaluate both emissions reduction goals and environmental justice concerns in communities that are disproportionately burdened by emissions related to the transportation sector.

Ease of Implementation: Could require legislative approval followed by regulatory action.

Example Policies and Programs – Transportation and Climate Initiative Program

Transportation and Climate Initiative Program (TCI-P), is a proposed program that, if implemented would be the United States' first cap-and-invest program focused on decreasing emissions from the transportation sector. In late 2018, nine states and the District of Columbia announced their intent to design a regional approach to cap GHG pollution from transportation. Massachusetts, Connecticut, Rhode Island, and the District of Columbia signed a Memorandum of Understanding in December 2020 that will require large gasoline and diesel fuel suppliers to purchase "allowances" for the pollution caused by the combustion of fuels they sell within the participating jurisdictions.[105] The funds from this program will be directed towards projects and programs that increase transportation access and electrification. This program is part of the larger Transportation and Climate Initiative, which works with an additional eight states to pursue clean transportation options in the Northeast and Mid-Atlantic region. Connecticut and Rhode Island are in the process of passing enabling legislation with the District of Columbia and Massachusetts authorized to begin the program. If it is fully adopted by the signatory states, the program could begin its first reporting year as early as January 1, 2022, with the first compliance period beginning one year later.

Fuel Standards

Low carbon fuel standards (LCFS) set annual carbon intensity (CI) standards for transportation fuels that include direct (e.g., producing, transporting, and using fuels) and indirect emissions (e.g., emissions associated with biofuel production). LCFS policies are set on a lifecycle basis that decreases over time. Fuels with lower carbon intensities than the standard receive credits that can be purchased by fuels with higher carbon intensities than the standard.

Fuel producers, just like automakers with fuel economy standards, are able to bank and trade credits in order to comply with the standard. Low carbon fuels that have a CI value below a certain threshold generate credits; fuels that are above a certain threshold generate deficits and must pay a fee if they exceed the credit amount.

While low-carbon fuel standards have only been implemented and approved in relatively few states, the impact of these policies on the development of ZEV programming throughout the state has been significant. Since implementing the program in 2011, the State of California has reduced the carbon intensity of its transportation fuel pool by 7.42 percent (6.25 percent of which is from biofuels) – aiming to reach 20 percent by 2030. The total value of credit transactions exceeded $2 billion in 2018 and have supported a number of programs focused on incentivizing fuel cell and battery electric vehicles and infrastructure within the state.[106] Estimates of the impact to consumers in California range from a cost of 19.9 cents per gallon for an E10 gasoline blend to 20.1 cents per gallon for a B3 diesel blend.[107] With regard to the sale of electricity, electric utilities generate base credits for the program based on both residential and non-residential charging. For residential charging, utilities are required to reinvest a minimum percentage of the revenue generated back into the state's Clean Fuel Reward Program, a statewide point-of-sale rebate for EVs. Non-residential charging, on the other hand, includes heavy-duty vehicle fleets.

In September 2020, the Colorado Energy Office commissioned ICF to produce a *Low Carbon Fuel Standard Feasibility Study* to evaluate the potential for an LCFS in Colorado including conducting a detailed analysis of Colorado's transportation fuels market.[108] Notably, the study found that:

- Colorado could achieve a 10 percent carbon intensity reduction over a 10-year timeframe with feasible and cost-effective changes to the transportation fuel supply with greater carbon intensity reductions from more aggressive and accelerated changes;

- The majority of credit generation would be through biofuels, at least for the first decade of implementation, rather than from electrification;
- The economic impact of compliance with a Colorado LCFS would have a negligible impact on forecasted growth within the state; and
- Alternative vehicle adoption, particularly transportation electrification, will play a larger role over the long-term as EVs are phased in.

Components

- **Consider including multiple pathways to generate credits:** This will enhance program implementation and drive programmatic goals (e.g., including capacity-based zero-emissions vehicle infrastructure crediting to encourage the development of hydrogen refueling and DCFC).[xxx]
- **Evaluate lifecycle emissions:** Ensure that indirect emissions associated with the development of certain types of fuel (e.g., land use implications of biofuels) are adequately evaluated.

Ease of Implementation: Would likely require legislative approval followed by regulatory action.

[xxx] Crediting for ZEV infrastructure is based on the capacity of the hydrogen station or EV fast charging site minus the actual fuel dispensed.

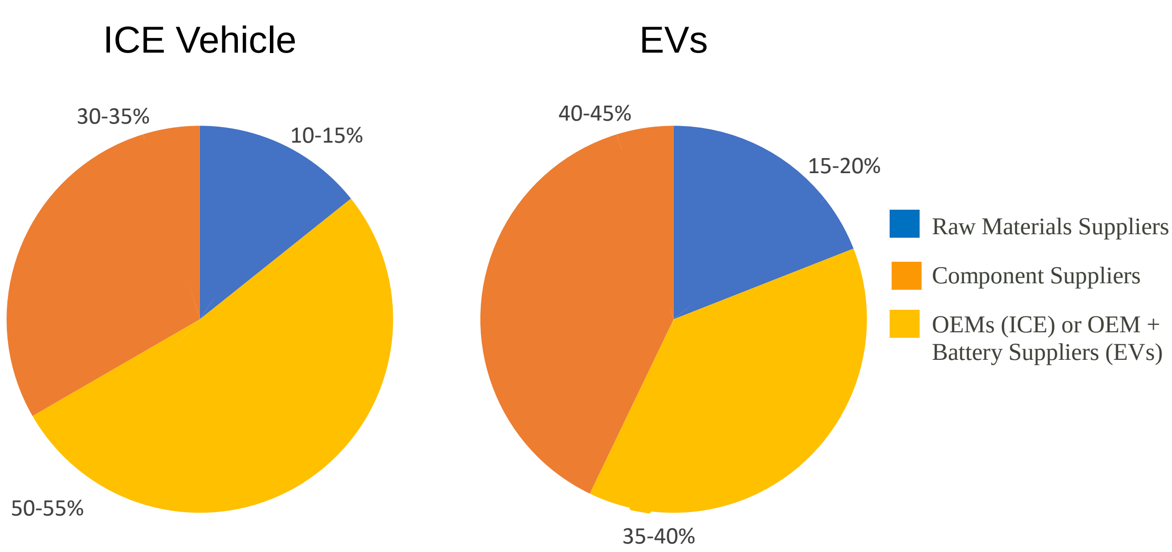
Supporting a Medium- and Heavy-Duty ZEV Industry

As M/HD ZEVs become a significant portion of the state's vehicle population, supply chain and workforce readiness will become increasingly important considerations for the state to evaluate and develop—in partnership with other stakeholders. The following section provides an overview of existing barriers to ZEV supply chains and workforce development and highlights some opportunities for collaboration amongst key stakeholders in the ZEV transition.

Supply Chain

As the percent of electric vehicles deployed throughout the U.S. grows, automakers and their suppliers will need to shift the current supply chain to accommodate electric vehicle components. Both ICE and BEV vehicles rely heavily on a global supply chain. The rise of electric vehicles will create a shift not only in where different components are produced but also in who is producing them. For example, in a typical ICE vehicle, raw material suppliers make up 10-15 percent of the total value of a new car with component suppliers making up 50-55 percent and OEMs making up the remaining 30-35 percent of vehicle value. In an electric vehicle, these value additions change with raw material suppliers accounting for 15-20 percent of vehicle value and component suppliers making up only 35-40 percent of the vehicle value with multiple OEMs or an OEM and a battery supplier accounting for the remaining value (see **Figure 23**).[109] **Figure 23** illustrates that the rise in electric vehicles will lead to a new supply chain that will have differing emission and environmental considerations. As the energy sector achieves alignment with the Paris Agreement, net reductions in life cycle emissions of EVs compared to ICE vehicles will increase. For vehicles and batteries manufactured in the U.S., especially in states with rapidly decarbonizing electric grids, these benefits can already be seen today.

Figure 23 Vehicle Manufacturing Components: Internal Combustion vs. Electric



One of the more significant supply chain concerns related to the rise in electric vehicles is the material sourcing and manufacturing of lithium ion batteries.[xxxi] Currently, the vast majority of existing battery manufacturing occurs in Asia (75 percent occurs in China alone).[xxxii] In recent years, new battery plants have been announced in Europe and, to a lesser extent, the U.S..[110] Tesla, GM, and Ford, among others,[111] have built or are in the process of building new EV battery factories in Ohio, Tennessee, Georgia, Michigan, and Nevada.[112]

Not only will increasing the domestic development of lithium-ion batteries provide greater supply chain independence as electric vehicle manufacturing increases but, from a greenhouse gas emission perspective, domestically manufactured batteries will have a significantly lower carbon footprint than the batteries manufactured in Asia where electric grids still utilize a significant amount of coal. Lithium raw material sourcing and production, and battery manufacturing are a significant portion of life-cycle emissions for EVs. Electricity is a significant input to both automotive and battery manufacturing, and different assumptions about grid carbon intensity drive much of life cycle emissions savings.

Workforce Development[xxxiii]

The status of vehicle technician training programs that incorporate ZEV into their curriculum varies. Across the country, there are a handful of more advanced training programs at community colleges that have integrated ZEV training tracks, but the development of a consistent and widely adopted training curriculum is not yet where it needs to be to support mass ZEV vehicle adoption – both for light-duty and M/HD vehicles. To date, ZEV adoption has been concentrated in California. This has led to the creation of multiple workforce development programs throughout the state. In the coming years, however, due to state ZEV targets and commitments from major fleets, the demand for ZEVs – and in turn the workforce to support them – is ramping up.

While there are a handful of programs nationwide today, each state will need to develop its own set of ZEV training offerings to support the creation of a local workforce. Community colleges are vital partners in providing robust training programs. Considerations that will be important in supporting workforce development programming include:

- **Funding:** Increased funding will be useful across program development but particularly with regard to vehicles and tools. In cases where colleges have pre-existing partnerships with OEMs, OEMs have and could continue to donate vehicles. There are a variety of options for financing. Beyond student tuition or certification fees, the most common funding source for program development is grants from state and local agencies or the National Science Foundation at the federal level. Increasingly, OEMs and suppliers are collaborating with community colleges and could contribute to program development. Collaboration with OEMs has been particularly useful in states like California and Michigan due to the concentration of manufacturer operations where curricula can cater to manufacturer-specific learning.

[xxxi] Lithium ion mining occurs primarily in South America (93 percent of the United States lithium imports come from Argentina and Chile), Australia and China. While the U.S. can increase, and likely will increase, its lithium mining operations, domestic battery manufacturing is likely to provide a greater opportunity for the country to have better control over its electric vehicle supply chain.
[xxxii] In 2018, the top five lithium ion battery producers by capacity were LG Chem, CATL, BYD, Tesla and Panasonic.
[xxxiii] MJB&A interviewed four community colleges and workforce training programs across the country and two in Colorado. This section highlights key takeaways developed by MJB&A based on those conversations.

- **Outreach:** Programs at community colleges cater to many different types of students with some students learning the trade for the first time and others looking for re-training opportunities during night programs. Several programs try to expose young students to a career as a technician by offering technical automotive classes to middle and, more commonly, high school students. While programs may be supported by national initiatives and funding, outreach and courses are most often conducted locally by the college itself.
- **Standards:** One standardized, national curriculum and test has not yet been adopted for ZEV technician training. Today, depending upon the curriculum, SAE International and Automotive Service Excellence (ASE) certification are both being utilized.[xxxiv] There are additional certifications and requirements from the Occupational Safety and Health Administration (OSHA) that will become even more important for those who work with higher voltage chargers for M/HD vehicles. Tying certification requirements to grant funding or policy requirements could help create more unified requirements for technicians and would further support the development of this emerging workforce and support the increasing demand in emerging technologies and fuels.
- **Infrastructure:** In addition to developing a workforce of technicians and engineers to support ZEVs, electricians must simultaneously be trained to support the growing ecosystem of chargers. For example, a collaborative of electric vehicle supply equipment (EVSE) providers, OEMs, utilities, and other ZEV stakeholders launched the Electric Vehicle Infrastructure Training Program (EVITP) in 2011. To date, the program has certified over 4,000 electricians in the proper installation of EVSE equipment after completing approximately 20 hours of training and a two-hour certification exam. Beyond partnerships with community colleges, EVITP has also worked with other accredited institutions and utility service centers.

Technician Training

Based in California, Rio Hondo's Automotive Technology Program has worked for decades to cultivate a well-trained workforce that will support light-, medium-, and heavy-duty ZEV vehicles. The program has adapted its curriculum over the years to support a range of fuel and vehicle types, currently providing tracks for gaseous fuels, fuel cells, and electric vehicles – a program for interconnected Tesla energy systems is under development. The program has seen success by partnering with a number of OEMs, including Volvo, Tesla, New Flyer and Ballard, among others, to link students with specific companies and their vehicle technologies. Most students are local but due to its success, the program has worked with students across the country and world.

For additional examples of workforce development programs nationally, see:

- The Center for Advanced Automotive Technology (CAAT) launched in 2010 at the request of Stellantis (formerly FCA) that combines academic coursework at Macomb Community College with paid on-the-job experience one day per week at a Stellantis manufacturing facility. Outreach includes: hosting events for middle and high school students annually with support from Ford, General Motors, Stellantis, and auto industry suppliers; offering career camps for middle school students; and hosting an Engineering Day event for Girl Scouts.

[xxxiv] Fuel cell vehicles will also have their own standards and requirements.

In Colorado, community colleges are already taking steps to support the ZEV workforce development but are not prepared for widespread deployment. Arapahoe Community College has been providing ZEV training on the light-duty side since receiving a U.S. DOE grant in 2011 to develop training programs for both technicians at independent repair facilities and dealerships. AIMS Community College has historically worked with M/HD diesel vehicles – class 7 and below – and is currently in the process of developing a curriculum in partnership with two other colleges for ZEV training and training templates that could be used by community colleges statewide that could be ready as soon as the 2022-2023 academic year. Both schools partner with a range of OEMs, including Volvo, GM, Nissan, Honda, Mercedes, Subaru, Ford, and Stellantis.

Components

- **Convening appropriate stakeholders:** Many community colleges have successful, long-standing relationships with OEMs but could benefit from an entity that is able to convene multi-stakeholder workgroups that could organize a coordinated approach to developing ZEV training programs across the state. For example, EVITP's development of a nation-wide curriculum was the result of the collaboration of 30 stakeholders across the automotive, utility, and EVSE manufacturing sectors with industry related professional associations and educational institutions.[113] CEO or another state agency could serve as an organizing body of the important stakeholders who should be active in developing a ZEV curriculum in a coordinated rather than siloed approach.
- **Providing capital**: Training programs will need test vehicles, the infrastructure to support them (e.g., EVSE or refueling stations), and the tools to conduct maintenance. While simulations may provide opportunity to some extent, nothing will compare to the hands-on experience of working on the vehicles themselves and navigating high-voltage systems. One potential point of collaboration could be establishing a network across the 13 Colorado community colleges to share tools. Some tools, like insulation testing meters and isolation gloves, could be purchased by each school given their relatively manageable costs. Others such as those that expose students and technicians to high voltage battery diagnostics, cell balancing, or power inverter modules can be quite expensive and model- and/or manufacturer-specific. Similarly, due to rapid advancements in the field, many tools may only be relevant for a few years before they are no longer compatible with newer models. Where feasible, shared tools may be more conducive to a collective network approach given these cost barriers if curriculums can be synched. The vehicles themselves should be school-specific because of how the vehicle is used within the classroom. In the past, some OEMs have donated vehicles through their individual partnerships with colleges.

Complementary Utility Actions

Electrifying regional and long-distance trucking cannot be done without the coordination and support of utilities across the state. Whether investor-, municipally-, or cooperatively-owned, utilities serve a variety of essential roles in the transportation electrification process. Although maturity of utility programs and experience in providing EV services varies – some are in initial stages while others have been supporting EV growth for years – utilities serve myriad roles. Utilities contribute unique expertise when participating in and providing technical assistance for regional corridor planning exercises and can serve as a trusted advisor and source of information when providing fleet advisory services. Utilities can also offer incentives and rebate programs that bring down the upfront cost of charging infrastructure or vehicles.

These actions cannot exist by themselves and often require the support of complementary policies and direction from regulatory bodies. For example, SB19-077 required Colorado's investor-owned electric public utilities to file an application for a program to support widespread transportation electrification within its service territory. As a result, Xcel submitted a proposal for a Transportation Electrification Plan, receiving approval at the end of 2020 for a $110 million program. Developing a coordinated approach that includes meaningful early engagement with utilities and other key stakeholders is imperative as planning and permitting is both timely and costly. Engaging utilities early on in the process can 1) lower vehicle electrification costs, 2) drive the strategic and equitable development of infrastructure that considers long-term electrification and grid management goals, and 3) ensure that fleet operators understand what is required to meet electrification targets.

Compared to the light-duty market, the M/HD vehicle market is in the early stages of development. Although utilities can leverage some learnings from light-duty electrification, the unique characteristics of M/HD vehicles require very different considerations. As was described in other sections of this report, the energy demand of M/HD vehicles is more significant when compared to a passenger vehicle. M/HD vehicles also vary significantly in their usage patterns and in the frequency and location in which they are able to charge.

Utilities, in coordination with other M/HD transportation stakeholders, can provide meaningful assistance to fleet operators and states as they begin to pursue M/HD transportation electrification policies and programs.

State and Regional Support for Utility Engagement in M/HD Vehicle Electrification

While there are many opportunities for utility engagement in M/HD electrification, utilities will need the cooperation and support of state leadership throughout the M/HD electrification process. State leadership can assist stakeholders across the EV value chain, including utilities, by developing the following:

- Comprehensive policies at the state and regional level provide many benefits, such as better-defined roles and long-term price signals, which can help to create a forum for coordination (including across state lines).
- Transparent targets and consistent markets signals that allow utilities to sequence critical grid investments, future proof, and implement resilience planning.
- Requirements (e.g., electric vehicle sales requirements) paired with incentives to increase adoption rates.
- Consistent and regular outreach to utilities. Utilities have unique insight into how to prepare for shifting electricity use cases and can apply lessons learned from LDVs to the M/HD vehicle sector.
- Streamline fueling experiences and costs for fleets operating in multiple service territories and/or states.

Opportunities for Utility Engagement in M/HD Electrification

Transportation electrification will require significant planning, logistics, and infrastructure development. When enabled, utilities can support M/HD transportation electrification by 1) educating and helping customers design fleet electrification plans, 2) offering incentives and, 3) by creating rate structures that both benefit customers and the electric grid.

M/HD vehicle electrification represents a new and significantly different challenge for all electric utilities including Investor-Owned Utilities (IOUs), cooperatives, and municipal utilities and will require adequate planning time and flexibility to ensure that infrastructure build-out is strategic and will meet both the short- and long-term needs of customers. The following sections highlight a number of ways that utilities can support state M/HD electrification goals.

Offering Advisory Services and Education

Utilities can help fleet operators see beyond the uncertainty of fleet electrification by offering targeted resources like fleet advisory services and detailed toolkits that provide key fleet electrification information in terms that fleet operators understand (e.g., discussing fuel cost savings in terms of $/mile instead of $/kWh). When enabled, utilities can also help reduce the administrative burdens associated with applying for incentive and grant programs by providing information on relevant programs and offerings that a fleet operator is eligible for.

Utilities can provide a suite of resources to assist the wide variety of fleet operators within their service territory—ranging from offering comprehensive one-on-one advisory services to developing easy to understand make-ready infrastructure applications. By offering a variety of approaches, utilities can help meet the needs of different customer sizes and fleet types. The need for these types of services will vary by customer size and unique fleet characteristics.

For example, while large fleet operators will need to coordinate with utilities to make sure they are able to adequately plan for load increases, large fleet operators may have a dedicated electrification team that is able to plan and project vehicle electrification and may not need additional support. For small to mid-sized fleet operators, on the other hand, a one-on-one approach may be the only way that a fleet operator considers transportation electrification or makes a thoughtful transportation electrification plan.

Fleet Advisory and Educational Tools

Southern California Edison's Charge Ready Transport program has developed a number of tools and online resources that allow the fleet operator to learn more about electrification options at their own pace and using language that is more familiar to a transportation expert as opposed to an electricity expert.[114]

For example, SCE's Electric Fleet Fuel Savings Calculator allows a customer to enter specific details about their vehicle type —including typical driving behavior and charging schedule—and provides costs savings in terms of dollar per mile instead of $ per kWh, thereby allowing fleet operators to easily compare an electric vehicle's "fuel costs" to their current diesel fleet. This "plug and play" option enables fleet operators to become more comfortable with potential electrification costs and savings, which may encourage early transportation electrification adoption. SCE has also developed a "Guidebook for Fleet Operators" which provides a step by step look at the key considerations to electrifying a fleet, including additional information on how to engage with SCE's existing programming.

For additional examples of resources to assist fleet operators in their electrification process, see:

- PG&E's EV Fleet Program has developed a Fuel Savings Calculator that offers fleets insight into electrification profiles.[115] A user can build a use case for each vehicle in their fleet which then offers insight into the minimum state of charge across the week. The tool allows the user to select from 14 vehicle type options, including SUV, Cargo Van, Transit Bus, and Step Van; enter the number of vehicles and average miles per vehicle per day; select days in operation; and estimate charging behavior when on the Business EV Rate. The tool then provides annual and per mile monetary savings (similar to SCE's method), annual GHG emissions savings, and potential to generate Low Carbon Fuel Standard Credits. The site also contains a list of PG&E, state, and federal grants available. After exploring the tool, users can then connect with a PG&E EV specialist.
- National Grid's Fleet Advisory Services offers assistance to customers within its Rhode Island and Massachusetts service territories.[116] To date, the program has served a number of medium- and heavy-duty fleets: government, public transit, colleges and universities, and school buses. This range has allowed National Grid to better understand the unique needs of different fleet operators. Since launching its Rhode Island program, National Grid has identified approximately seven million pounds of CO_2 savings and $900,000 of lifetime savings for participating customers.
- Utilizing funds from the State of Oregon's Low Carbon Fuel Standard, Portland General Electric's Drive Change Fund provides support to community organizations, nonprofits, and businesses to advance EV and infrastructure deployment and provide EV education.[117] This type of assistance, when paired with the technical expertise that electric utilities can offer to grant recipients, can enable fleet operators that would otherwise not be able to purchase an EV to consider electrification.
- In December 2020, Xcel Energy received approval for its Transportation Electrification Plans which includes fleet advisory services for M/HD fleets. Xcel partnered with Sawatch Labs to utilize a specific fleet's data to evaluate current fleet operations and to determine which fleet vehicle's driving needs could be met with an electric vehicle.

Designing Utility Rates to Encourage Resilient and Cost-Effective Charging Behavior

Implementing effective rate design can enable fleet operators to cost effectively electrify and can ensure that utilities will be able to efficiently manage new M/HD vehicle charging load in a way that does not negatively impact grid reliability.

IOUs, cooperatives, and municipally owned utilities are all subject to different rules and regulations which may lead them to pursue one load management strategy over another. Utilities and state agencies should work together to evaluate which approach, or approaches, may work best within a given utility service territory. The following approaches highlight a few ways in which utilities across the country are pursuing changes to their rates to promote managed charging.

Sector-specific rates: Sector-specific rates target M/HD vehicles by offering a specific tiered rate structure for different categories of M/HD vehicles. For example, a utility could provide a transit fleet rate that is designed to match the duty cycle and usage pattern of the transit vehicle to encourage the fleet operator to develop a managed charging strategy. Sector specific rates can be very useful for M/HD fleets that have very consistent load and usage patterns but need to be tiered effectively to accommodate the different types of vehicles that make up the M/HD vehicle sector.

Tailoring rates to meet specific customer needs: Tailored rates are not necessarily specific to electric vehicle use but target a certain behavioral shift from customers—either incentivizing or disincentivizing a behavior beyond what is typically included in a traditional rate. Some utilities offer time-of-use (TOU) rates, for example, that incentivize customers to reduce their consumption during peak usage hours. Others offer rates that incentivize service offerings that are beneficial for the community at large. Tailored rates offer another way to modify rate structure to encourage managed charging without developing a rate that only targets one specific customer segment.

Incentives placed on top of existing rates: Some utilities have found that incentive programs can be a useful near-term option to encourage managed charging when compared to implementing specific or tailored rates. Since incentive programs are not tied to a ratemaking process, incentives can be modified more quickly and can be designed to be targeted towards customers with low, medium, and high usage rates. While these may be easier for utilities to implement and change, incentive programs may require additional communication and outreach to customers to ensure that eligible customers are aware of these program offerings.

Utilities across the country are developing pilots and programs that attempt to improve managed charging. As was described above, the method for implementing these programs varies depending on existing legislative and regulatory guidance within the state. The following examples highlight several different ways in which utilities are approaching charging solutions.

Sector Specific Rates

PG&E offers two Business EV rate plans for customers with on-site EV charging— a low use EV rate for smaller workplaces and multi-unit dwellings and a high use EV rate for fleets and fast-charging stations.[118] Customers receive a separate meter and then choose between a variety of monthly subscriptions plans that are based on the customers maximum monthly EV charging consumption, which can be adjusted over the course of the month depending on the fleet's consumption levels.

If a fleet's actual consumption exceeds the subscription level, the fleet is charged an average fee of two times the cost of one kW for each kW that exceeds the subscription level. In order to ensure that customers are able to choose the appropriate subscription model that aligns with their fleet's usage, fleets are given a grace period of three billing cycles when they sign up for the program to better understand their usage patterns. In addition to the monthly subscription charge, customers are charged a TOU rate based on how much energy the customer actually consumes and when. These types of programs allow fleet operators to better understand and manage their costs and also allows utilities to gather important load data that can enable them to better understand and manage their load in the future.

Tailored Rates

PacifiCorp utilizes two different seasonal TOU rates that target evening peak during the spring and summer months and that target both evening and morning peaks during the winter months.[119]

Another way in which utilities can modify customer behavior is by offering reduced rates that incentivize customers who provide a particular service. Con Edison's Business Incentive Rate for customers within New York City and Westchester County, for example, offers reduced energy rates to commercial businesses that meet rate eligibility criteria which ranges from reoccupying a vacant commercial or industrial building to constructing a publicly accessibly electric vehicle quick charging station.[120] By creating this type of rate structure, utilities build in incentives that lessen the risk that customers face when implementing policies that may have higher upfront costs.

Incentives on Existing Rates

Con Edison's SmartCharge New York program uses a FleetCarma tracking system to reward EV drivers for off-peak charging.[121] Participants who charge in the Con Edison service territory receive $150 for installing and activating the FleetCarma monitoring device, $5/month for continuing to charge in the service territory and a bonus $20/month for avoiding summer-peak charging weekdays between the hours of 2 PM to 6 PM and $0.10/kWh for charging between midnight and 8 AM year-round. Additionally, participants can receive bonus payments for installing their device within one week, submitting feedback through annual surveys, and referring additional customers. Unlike TOU rates, SmartCharge New York is an off-bill, nontariff program that monitors charging through a tracking system installed in the vehicle. Non-fleet participants receive their incentive on a monthly basis through PayPal and fleet participants receive rewards by check.

Developing a Coordinated Approach to Transportation Electrification through Utility Transportation Electrification Plans and Studies

Developing a charging network for M/HD vehicles—in particular, for long-haul and regional trucking—will take years even under the most ideal circumstances. While many fleets are likely to utilize depot charging, as electrification expands to include regional- and long-haul trucking, vehicle operators will need to be able to understand 1) how their electricity prices vary from one service territory to the next and 2) when to charge their vehicle in order to reduce electricity costs and avoid demand charges. Even with depot charging—depending on how many depots the fleet operator owns and where those depots are located—a fleet operator may still need to understand multiple different utility rate structures if they own depots that exist within two or more service territories.

Utilities can provide essential insight about grid expansion costs and time requirements and they have an important role to play in electrifying regional and long-distance trucking by participating in electrification planning exercises, providing technical assistance to fleet operators, and developing their own transportation electrification plans.

If utilities are unable to plan for future electrification at scale, infrastructure development over the long term could be costlier and time consuming. Electricity costs will be a significant consideration for M/HD vehicle operators considering electrification.

There are several different ways in which utilities can support the development of a coordinated approach to transportation electrification. The following points highlight a few key considerations that should be evaluated in utility transportation electrification plans or studies:

- **Data collection**: Continuing to gather information and data on customer usage can help utilities improve offerings over time and should be a core element of program and study participation.
- **Flexibility in program design to account for the variability in the M/HD vehicle market:** Both programs and studies should consider the various usage patterns and charging needs of multiple types of M/HD vehicles.
- **Increased collaboration across utilities throughout the state and region:** Transportation electrification, unlike other forms of utility investment, will require increased coordination across service territories simply because the vehicles themselves are moving across service territories—sometimes multiple— in a given day. Utilities and their regulators need to work together to ensure that their M/HD vehicle customers are able to reliably perform their duties both within their service territory, and eventually, throughout the state and region. IOUs, cooperatives and municipally owned utilities will need to work together to create a consistent fueling experience for fleet operators. Implementing this type of state-wide or multi-service territory approach will likely require state leadership and regulatory flexibility.
- **Evaluate cost of M/HD vehicle deployment and provide options for reducing costs:** Within both utility transportation electrification plans and in transportation electrification studies, utilities should evaluate cost and, where appropriate, evaluate incentive programs and utility infrastructure programs that can reduce customer cost to increase deployment.

Engagement Across Utility Service Territories

The CHARGE EV Network provides an example of collaboration among 29 electric cooperatives to create a regional EV charging network across Wisconsin, Minnesota, Illinois, and Iowa with the intention of encouraging co-op consumer-members to drive EVs. The 29 cooperatives collectively invested over $100,000 that will go into a network of 40 Level 2 and DCFC chargers installed near major highways and interstates.[122]

Although this effort is focused on light-duty electrification, the initiative demonstrates that cooperatives understand the important role they will play in connecting their members with the benefits of electrification. This collaborative allows co-ops, which often do not have the resources or capital to invest in EV infrastructure independently, to invest as a unit. As one member said, "being a smaller cooperative, Dunn Energy jumped at the chance to collaborate with other electric cooperatives to form CHARGE EV. By working together, we can help our members and non-members alike feel more comfortable purchasing an electric vehicle in our region." The collaborative offers resources beyond charger deployment, like informational material for co-ops to educate members, electricians, and dealerships.

As these Midwestern co-ops prioritize vehicle electrification, Colorado co-ops could look to contribute to the growth of this network: one CHARGE EV member, Pierce Pepin Cooperative Services, sees potential for a national co-op EV brand and charging network in the near future.

Learning from Existing Utility Programs

Colorado utilities have a history of working together on other clean energy offerings, such as rolling out energy efficiency programs. While requirements for municipal utilities or electric cooperatives are more limited when compared to requirements mandated for IOUs within the state, many still offer robust energy efficiency programs – even working collaboratively on certain offerings.

Efficiency Works is an energy and water efficiency partnership between the municipally-owned utilities of Estes Park Power & Communications, Fort Collins Utilities, Longmont Power & Communications, Loveland Water and Power, and Platte River Power Authority in northern Colorado.[123] Since launching in 2014, the program has upgraded 4,500 businesses and served 9,000 residential customers, saving over 123,000 MWh of energy. Each utility provides funding to support the program, but funds are not transferred among communities, ensuring that ratepayers are only helping fund programs in their communities. The coordination has facilitated access to information by creating one central clearinghouse for efficiency offerings and resources.

By considering prior collaborative efforts, information clearinghouses, and approaches, utilities can look to apply these learnings towards EV offerings and work towards how best to offer a continuous experience no matter where in the state EV drivers go or in what utility service territory they charge. Energy efficiency programs, in particular, may provide insight into how to demonstrate to consumers the lifetime cost savings benefits of electric mobility even though the upfront cost may be greater.

Ensuring Equity in State-wide M/HD Transportation Electrification

Utilities can help to ensure that the electric M/HD vehicle market scales in an equitable way that simultaneously meets statewide electrification goals and benefits disproportionately impacted communities in the near term by targeting and supporting electrification in areas that may otherwise be difficult to electrify. There are a number of ways in which utilities can support the equitable distribution of M/HD electrification.

The first is by prioritizing the near-term development of charging infrastructure to support the electrification of M/HD vehicles that travel through and are domiciled in communities that are disproportionately burdened by poor air quality due to elevated levels of PM, NOx, and other vehicle emissions. The targeted electrification of these vehicles (e.g., school buses, transit buses, and —for communities located near freight corridors or that host distribution centers, warehouses, and fleet depots—trucks) can lead to lower levels of asthma, lung and heart disease, and premature death. Supporting ZEV infrastructure development in disproportionately impacted communities can both target fleets domiciled in the area as well as encourage the vehicles servicing the facilities to convert to zero-emitting vehicles.

It is critical that a M/HD vehicle electrification strategy is coordinated and implemented in a way that incorporates a focus on low-to-moderate income (LMI) and EJ communities. Utilities, when enabled, can assist in ensuring the charging infrastructure is prioritized in disproportionately impacted communities by setting infrastructure deployment targets. This is already being done in the light-duty sector in public utility commissions across the country and in Xcel's Transportation Electrification Program in Colorado where ratepayer funded utility make-ready infrastructure programs offer increased incentives for make-ready infrastructure deployed in LMI, multi-family housing, and disproportionately impacted communities.

The second key step to ensuring that M/HD vehicles are equitably deployed is by ensuring that communities across the state are able to electrify their M/HD fleets—including rural communities that are supported by smaller cooperatives. State leadership is needed to make sure that these communities are not forgotten in this transition and that the local utilities have the support they need in order to develop charging infrastructure within their service territories. As discussed previously, M/HD transportation electrification will require tremendous coordination amongst stakeholders across the vehicle value chain and will necessitate increased cooperation and coordination between different electric utilities.

Understanding the Role of State Regulators in Approving Utility Programming

As discussed previously, there are a wide variety of ways that utilities can provide support and help enable a coordinated approach to transportation electrification. For IOUs, almost all of the programs described above will require regulatory approval with municipal utilities and cooperatives having varying degrees of state oversight. Each utility is subject to different existing state and regulatory rules and timelines, all of which will impact how a utility is able to pursue transportation electrification programs or policies.

For example, regulated utilities often undergo ratemaking proceedings on a scheduled two- to four-year basis. These proceedings are the primary way for regulated utilities to gain approval for new programs (including advisory services, rate design, or other incentives) and investments (such as make-ready infrastructure or distribution upgrades) that will be necessary to support growing M/HD vehicle demand.

During rate-making proceedings, utilities are often held to very strict requirements for receiving rate recovery to ensure just and reasonable rates. While it is important to ensure that costs remain reasonable for customers, as utilities begin to develop their M/HD vehicle electrification programs and infrastructure incentives, it will be important for them to have enough flexibility to change programming tactics—including developing more innovative solutions to managing load— in order to ensure that state M/HD vehicle electrification targets can be met.

Understanding the Role of State Leadership and Utility Regulators in Utility Transportation Electrification Programming

In order to ensure that utilities are able to develop programming that supports the growth of M/HD vehicle electrification, states and regulatory bodies should work to develop a consistent long-term policy leading up to and across these ratemaking cycles will ease regulatory review and allow utilities to propose the proactive and cost-effective solutions to aid electrification effort in the following ways:

- Define a role for utilities in M/HD electrification to help drive planning, coordination, and program development in addition to helping maintain consistency for customers;
- Consider ways to provide flexibility to enable and support this type of dynamic market development; and
- Assist in developing cooperation between utilities (including between differing types of electric utilities).

The two examples described below offer ways in which—with greater regulatory flexibility— utilities and their customers could create more efficient and dynamic program development.

- **Allow anticipatable upgrades if it is indicated by mid- or long-term needs:** If a customer is planning to add additional electric M/HD vehicles over the course of a few years and those vehicles will require the utility to upgrade a substation or other electrical infrastructure, it might make sense for the utility to make the necessary upgrades to their system while the initial infrastructure upgrades are occurring so that infrastructure complications can be avoided for future charger upgrades.

- **Enable greater flexibility in overall funding:** Traditional funding for utility infrastructure programs is often capped which prohibits additional short-term expense. In some situations, utilities may find that they experience an influx in requests for charging infrastructure within a given year but will be unable to meet those requests because their multi-year program has yearly budget caps that would prohibit additional expenses.

Increasing Program Flexibility

While each state and jurisdiction would have to determine how to appropriately enable utility flexibility, the State of Colorado's recent approval Xcel's Transportation Electrification Program provides one example regulatory flexibility.[124]

Xcel, within its Transportation Electrification Program proposal, requested that the Commission allow increased flexibility surrounding annual program funds in addition to enabling the utility to move funds within and between its electrification programs. The Commission approved this request allowing Xcel to move funds between portfolios—subject to a cap of 150 percent— and to increase the budget up to 125 percent of annual estimated costs, stating, "this flexibility will allow [Xcel] to efficiently address the evolving market and expand or contract programs in response to customer demand and market costs." This type of increased flexibility can allow utilities to be dynamic in the beginning stages of their program development enabling them to be responsive to their customers' evolving needs without having to wait for the next utility rate case —which typically occurs every two to three years—or to file a petition to amend a program which can also be time consuming.

Understanding Benefits

If M/HD electrification is undertaken strategically and intentionally, communities, utilities, and their customers will benefit.

M/HD vehicle charging will create net revenues from increased grid utilization thereby reducing rates broadly across customer classes. To realize these benefits, it is critical that the infrastructure development necessary to support growing electric M/HD fleets is built in coordination with other parties through mid- and long-term planning — drawing upon other grid modernization and development efforts. This will help minimize costs and maximize customer benefits.

Understanding and Accounting for All Benefits from Electrification

While utilities have the potential to benefit from increased transportation electrification, the main driver for these programs are the environmental and societal benefits associated with decarbonizing the transportation sector.

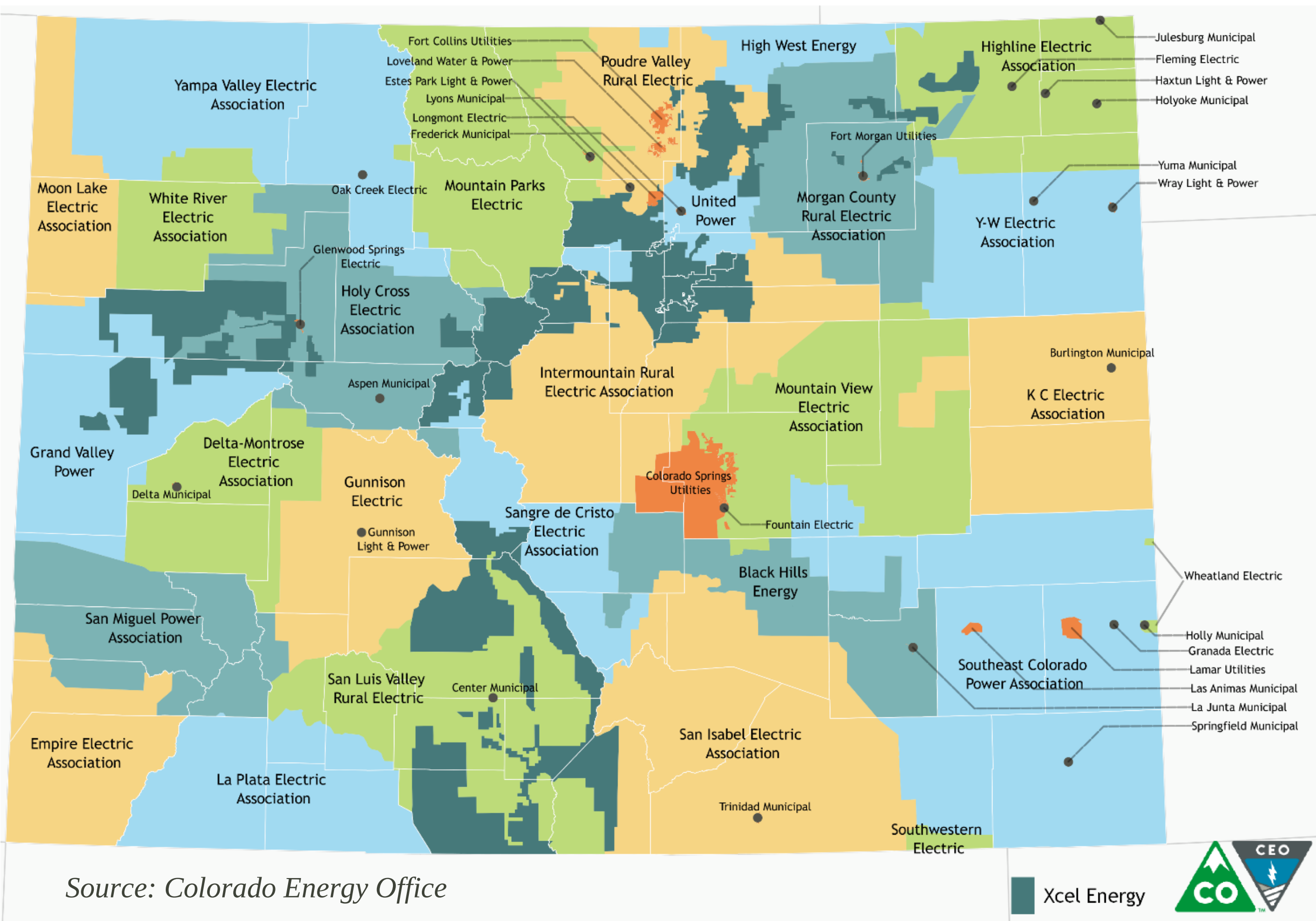
In order to ensure that utilities are able to develop programming that supports the growth of M/HD vehicle electrification, states and regulatory bodies need to consider the following:

- Ensure that state cost-benefit analyses include the health benefits associated with reduced emissions.
- Include and outline the importance of early and frequent utility engagement in state transportation electrification planning.

Existing Colorado Utility Programming

Two investor-owned utilities serve Colorado: Xcel Energy and Black Hills Energy. While they serve a majority of customers in the state and may have the most capital to invest in ZEV programs, they only make up a small portion of the geographic area of the state (**Figure 24**). Municipal utilities and cooperatives will be essential actors to ensure a coordinated, effective, equitable, and continuous ZEV rollout across the state. Although Colorado's municipal utilities and cooperatives have focused on light-duty EV offerings to date, their work illustrates an eagerness to explore how transportation electrification can expand clean mobility opportunities for their members and customers.

Figure 24 Colorado's Investor-Owned, Cooperatives, and Municipal Utilities



Source: Colorado Energy Office

Investor-Owned Utilities

The importance of the IOU role in EV deployment is unequivocal. Regulated by the Colorado Public Utilities Commission (PUC), IOUs must file rate cases and receive PUC approval before spending ratepayer funds. While this creates unparalleled opportunity with regard to capital deployment (e.g., Xcel's $102 million Transportation Electrification Program [TEP]), approval processes and schedules, as was described above, can at times delay program implementation and can limit program flexibility.

Xcel Energy[125]

Goals:

- Serve customers with 80 percent carbon-free electricity by 2030 and 100 percent by 2050
- Electrify all the sedans in Xcel's own fleet by 2023 moving to electrify entire light-duty fleet and 30 percent of M/HD vehicle fleet by 2030
- Powering 1.5 million EVs across three states served by 2030; in Colorado, Xcel estimates there will need to be around 450,000 ZEV vehicles in its territory by 2030 to meet the state's goal – growing to nearly 100,000 in the next three years
- $1 or less per gallon to drive an EV when charged with Xcel's off-peak electricity prices

Overview:

- Colorado's largest IOU, serving over half of the state's electricity needs
- $110 million Transportation Electrification Program approved January 2021 – will commit a minimum of 15 percent of all funding to low-income customers and underserved communities
- ZEV strategy: 1) raising awareness and increasing access to information on the benefits of EVs, 2) helping reduce the upfront costs of infrastructure needed to change EVs, and 3) establishing time-varying rates and smart charging technologies to ensure that EVs can charge as much as possible on low-cost, low-carbon energy

Rates:

- EV Critical Peak Pricing rate: for commercial and industrial customers; offers even lower prices during off-peak times compared to the alternative S-EV rate. While on this rate, fleet operators must shift their charging away from a period when Xcel calls a critical peak event.
- Denver's Regional Transportation District (RTD) operates the largest fleet of electric buses in the country with 36 active vehicles. RTD estimates that it could save at least 30 percent on annual energy costs thanks to this rate.

EV Purchase Rebates:

- TEP includes offering an "equity rebate" for new and used EVs for low-income qualified customers

Infrastructure:

- TEP includes deploying approximately 20,000 charging stations at residential, commercial, and public sites across the state, including rebates for residential and multi-family dwelling customers
- TEP will supporting additional stations through make-ready infrastructure

Fleet Advisory:

- Fleet advisory service for a fleet of five or more LDVs through which Xcel collaborates with fleets on vehicle replacement and infrastructure needs assessments (*also offering Fleet EV Service Pilot in Minnesota)*

Notable M/HD Vehicle Projects:

- RTD is currently one of Xcel's largest EV customers. They have participated in Xcel's Transportation Electrification Workshops, provided feedback on Xcel's EV rates, and served as an intervener in the EV Critical Peak Pricing rate hearing.
- In Minnesota, Xcel has worked with three major clients – Metro Transit, the Minnesota Department of Administration, and the City of Minneapolis – as well as trucking fleets through its Fleet EV Service Pilot program

Black Hills Energy[126]

Goals:

- 80 percent reduction in GHG emissions from its electric generation operations by 2030, compared with a 2005 baseline

Overview:

- EV Ready program provides rebates for chargers for residential and business customers

Rates: *Does not offer EV-specific rates*

EV Purchase Rebates: *No EV purchasing rebates offered*

Infrastructure:

- Does not have a coordinated infrastructure investment
- Ready EV program: residential customers can receive a rebate of $500 for a Level 2 charger; businesses can receive up to $2,000 per port for a Level 2 or $35,000 for a DCFC

Fleet Advisory: *No fleet advisory service offered*

Notable M/HD Vehicle Projects: *No notable projects to date*

Municipal Utilities

Led by a local city council or elected commission, Colorado's 29 municipal utilities have a unique role due to their close alignment to supporting the needs and ambitions of their municipality or city. Municipal utilities will be key partners as the cities they serve set climate targets and roadmaps, which include transportation components. Two examples are included below.

City of Fort Collins Utilities[127]

Goals:

- 20 percent reduction below 2005 levels in 2020; 80 percent below by 2030; and carbon neutral by 2050

Overview:

- EV-Readiness Roadmap (2018): offers short- (1-2 years), medium- (3-5 years) and long-term (10+ years) policies and incentives the city can provide as well as utility-specific actions, which include: supporting smart grid operations for EVs; increasing renewable electricity for EV charging; assessing and adjusting utility rate structures for EV drivers; and upgrading electricity distribution infrastructure.

Rates:

- No residential or business rate but provides charging for a flat rate of $1/hour for seven public stations

EV Purchase Rebates:

- EV Group Buy Program (2020): provided discounted rates for certain EVs through a partnership with Northern Colorado Clean Cities; 2020 program resulted in 87 discounted EVs sold

Infrastructure:

- Upgraded local charging stations at seven locations

Fleet Advisory: *No fleet advisory service offered*

Notable M/HD Vehicle Projects: *No notable projects to date*

Colorado Springs Utilities[128]

Goals:

- 20 percent reduction below 2005 levels in 2020; 80 percent below by 2030; and carbon neutral by 2050

Overview:

- EV Readiness Plan: under development and will include conversion roadmaps for utility fleets as well as the identification of EV charging station locations, including needed utility infrastructure upgrades

Rates:

- TOU Rate: for residential and business EV customers – on-peak hours are 3 PM to 7 PM April through September and 4 PM to 10 PM October to March

EV Purchase Rebates: *No EV purchasing rebates offered*

Infrastructure: *No utility infrastructure investment*

Fleet Advisory: *No fleet advisory service offered*

Notable M/HD Vehicle Projects: *No notable projects to date*

Cooperatives

As rural electric cooperatives are made up of a collection of smaller utilities, they can band together to create unique EV opportunities for their smaller member bases. With 22 cooperatives across the state, Colorado's co-ops are led by a board of elected members who understand the unique needs and circumstances of their communities and service territories.

Moving beyond light-duty offerings to M/HD vehicle support may be a challenge for cooperatives given the greater energy needs of fleets. Similarly, IOUs receive a rate of return on capital investments like chargers, but cooperatives may encounter obstacles when looking to invest in costly M/HD solutions as action will require multi-member cooperation and approval.

Holy Cross Energy (HCE)[129]

Goals:

- Will transition its own vehicle fleet over time (*no concrete timeline*)

Overview:

- EV program is charging solution focused with its "Charge at home. Charge at work." program

Rates:

- Time of Day rate with on peak hours 4 PM to 9 PM, seven days a week

EV Purchase Rebates: *No EV purchasing rebates offered*

Infrastructure:

- Charge at home. Charge at work. program: up to two free chargers per member. HCE owns the Level 2 charger (both residential and commercial offerings), pays local contractors for installation, agrees to maintain the EVSE for three years, and recovers the costs through a standardized fixed charge on the member's utility bill.
- Developing a public DCFC network

Fleet Advisory: *No fleet advisory service offered*

Notable M/HD Vehicle Projects:

- Partnering with local mass transit partners to install the infrastructure necessary to support their electrification needs

Tri-State Network – Gunnison County Electric Association[130]

Goals:

- Tri-State will be submitting a "preferred scenario" to reduce emissions associated with its wholesale electricity sales in Colorado by 80 percent by 2030

Overview:

- The Tri-State Network is made up of 45 member cooperatives across four states who are leveraging this network to support EV offerings through shared test drive vehicles
- Ride and Drive – EV Experience Fleet (2020): Tri-State member cooperatives can borrow BEV and PHEVs for up to a month for staff use and to conduct Ride & Drive events. Through Ride & Drive events, Tri-State members bring EV access to rural Colorado, allowing local cooperatives to understand and rectify EV challenges specific to their service territory – especially for those who fear that EVs cannot uphold performance during Colorado's winters. Program is available to utility employees, cooperative members, and public power district consumers.

Rates:

- TOU Rate: customers receiving a charger rebate must sign up for the TOU rate, 5 PM to 10 PM, Monday through Saturday

EV Purchase Rebates: *No EV purchasing rebates offered*

Infrastructure:

- Residential rebate for 70 percent, up to $500, of the cost of a Level 2; 50 percent, up to $250, to upgrade garage plug to 240-volt outlet
- Charge at Home program: Free Level 2 charger for customers who share their charging data
- Owns and operates twelve public charging stations in Gunnison and Hinsdale counties
- Committed to spend nearly $2 million to help each of its members install EV chargers in their service area

Fleet Advisory: *No fleet advisory service offered*

Notable M/HD Vehicle Projects: *No notable projects to date*

Modeling Potential Medium- and Heavy-Duty ZEV Penetration Scenarios

Various strategies for a M/HD ZEV transition presented earlier can have meaningful co-benefits. The M.J. Bradley & Associates' proprietary STate Emissions Pathway (STEP) Tool and Toolkit for Advanced Transportation Policies were used to model net benefits and costs of certain policies.[xxxv] To evaluate the results of different policies, a set of three individual scenarios were developed and modeled and then compared against a baseline that assumes no additional ZEV transition drivers beyond current market trends. The baseline scenario is based on future annual VMT and fleet characteristics as projected by U.S. Energy Information Administration (EIA) as part of their Annual Energy Outlook data series for 2021 (Reference case).

- **ACT Scenario** – Models the impacts of Colorado adopting California's Advanced Clean Trucks Rule. ZEV sales are assumed to be battery electric vehicles and will be the majority of M/HD vehicle purchases in 2035 and beyond.
- **ACT + NOx Scenario** – Builds upon ACT scenario by adding California's requirement that 100 percent of M/HD vehicles sold in the state that are not ZEV must meet a low-NOx emission limit after 2024. New vehicles must meet a 75 percent reduction in NOx emissions in 2024, increasing to 90 percent reduction after 2027.
- **100 X 40 Aspirational Scenario** – Further builds upon the ACT + NOx scenario by increasing ZEV sales to 90-100 percent by 2040. ZEV and Low NOx vehicles make up 98 percent of vehicles in the state by 2050. It should be noted that this scenario assumes that the state and federal government adopt additional policies to increase ZEV adoption; however, these individual policies have not been contemplated in the context of this analysis. This is the most aggressive scenario analyzed and represents a suite of options that may be possible; this scenario was defined to attempt to set an upper bound, but may not be feasible to implement.

The assumptions in the GHG Roadmap for ZEV adoption in the M/HD sector include 40% M/HD ZEV sales by 2030 and 100% by 2050, and the Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding includes similar targets, reaching 30% ZEV sales by 2030 and 100% by 2050. These assumptions align approximately with the ACT Scenario in 2030, and with the 100 X 40 Aspirational Scenario in 2050.

For each scenario, this analysis also calculates the total incremental cost of purchase and operation for all ZEVs in the state, compared to "baseline" purchase and operation of gasoline and diesel M/HD vehicles. For both ZEVs and baseline vehicles, costs include the incremental cost of purchasing the vehicle, costs for fuel and electricity consumption, and maintenance costs. For EVs it also includes the charging infrastructure costs, including equipment maintenance.

Under each scenario, this analysis also calculates tailpipe GHGs, NOx and PM emissions for gasoline and diesel vehicles and compares them to "upstream" emissions from electricity generation for vehicle charging or hydrogen fuel processing for fuel cell vehicles. For the baseline and penetration scenarios, GHG emissions are expressed as CO_2e, while NOx and PM are simply in metric tons (MT).

For each scenario, GHG emissions from ZEV charging are calculated based on a "Low carbon electricity" scenario. The low carbon electricity assumption is based on Colorado achieving 68 percent renewable energy

[xxxv] The analysis applies the ACT rule across all M/HD vehicle types, which differs from the CA ACT rule which exempts transit buses and other buses that are subject to the Innovative Clean Transit Rule.

by 2030 and 94 percent carbon-free electricity generation by 2050, similar to the assumptions for the 2019 Action Scenario in the GHG Roadmap.

Net annual GHG reductions from the use of ZEVs are calculated as baseline GHG emissions (emitted by gasoline and diesel vehicles) minus GHG emissions from each scenario. The monetized “social value” of these GHG reductions from ZEV use are calculated using the Social Cost of Carbon ($/MT), as well as social costs for CH_4 and N_2O gases.[xxxvi]

The Social Cost of Carbon is a measure of monetized future damages resulting from the increase of carbon dioxide emissions and is expressed as current dollars per metric ton of pollutant. These monetary damages include (but are not limited to): flood-related property damage, decreased agricultural crop production, reduced human health, and loss of climate-change-related ecosystem services. The Federal government created the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG), which is tasked with maintaining current social costs of pollutants. The IWG operated from 2009-2017, before being disbanded by the Trump Administration. When the Biden administration took office in 2021, the IWG was reconvened and continues to maintain current estimates of social costs.

NOx and PM emission reductions for ZEV use are also monetized for this analysis and are based on EPA’s CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA). See **Table 10** for a summary of the monetized air quality avoided cost assumptions along with the social values for GHGs.

Table 10 Monetized Benefits for GHGs, NOx and PM

2020 $/MT			2020	2030	2040	2050
GHG	CO_2	2.5% Discount Rate	$76	$90	$103	$117
	CH_4		$1,966	$2,457	$3,194	$3,808
	N_2O		$27,026	$33,168	$39,310	$45,452
NOx	Vehicle Tailpipe		$9,035	$10,261	$11,474	$12,700
	Electricity Generation		$3,394	$3,854	$4,310	$4,770
	Petroleum Fuel Production		$13,766	$14,690	$15,452	$16,089
PM	Vehicle Tailpipe		$228,585	$259,583	$290,287	$321,303
	Electricity Generation		$75,925	$86,222	$96,420	$106,722
	Petroleum Fuel Production		$237,674	$253,636	$266,779	$277,777

Based on assumed future ZEV characteristics and usage, the analysis projects annual electricity use for ZEV charging at each level of penetration. The analysis then projects the total revenue that Colorado’s electric distribution utilities would realize from the sale of this electricity, their costs of providing the electricity to their customers and the potential net revenue (revenue in excess of costs) that could be used to support maintenance of the distribution system, which could result in reduced costs for ratepayers over time.

[xxxvi] Consistent with Colorado state legislation, this analysis uses values from the Interagency Working Group on Social Cost of Greenhouse Gases, “Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis” August 2016 (CO_2) and “Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide, August 2016 (CH_4 and N_2O)

The costs of serving charging load for the additional peak load resulting from ZEV charging include: (1) the cost of electricity generation; (2) the cost of transmission and incremental peak generation capacity; and (3) transmission and distribution capacity.

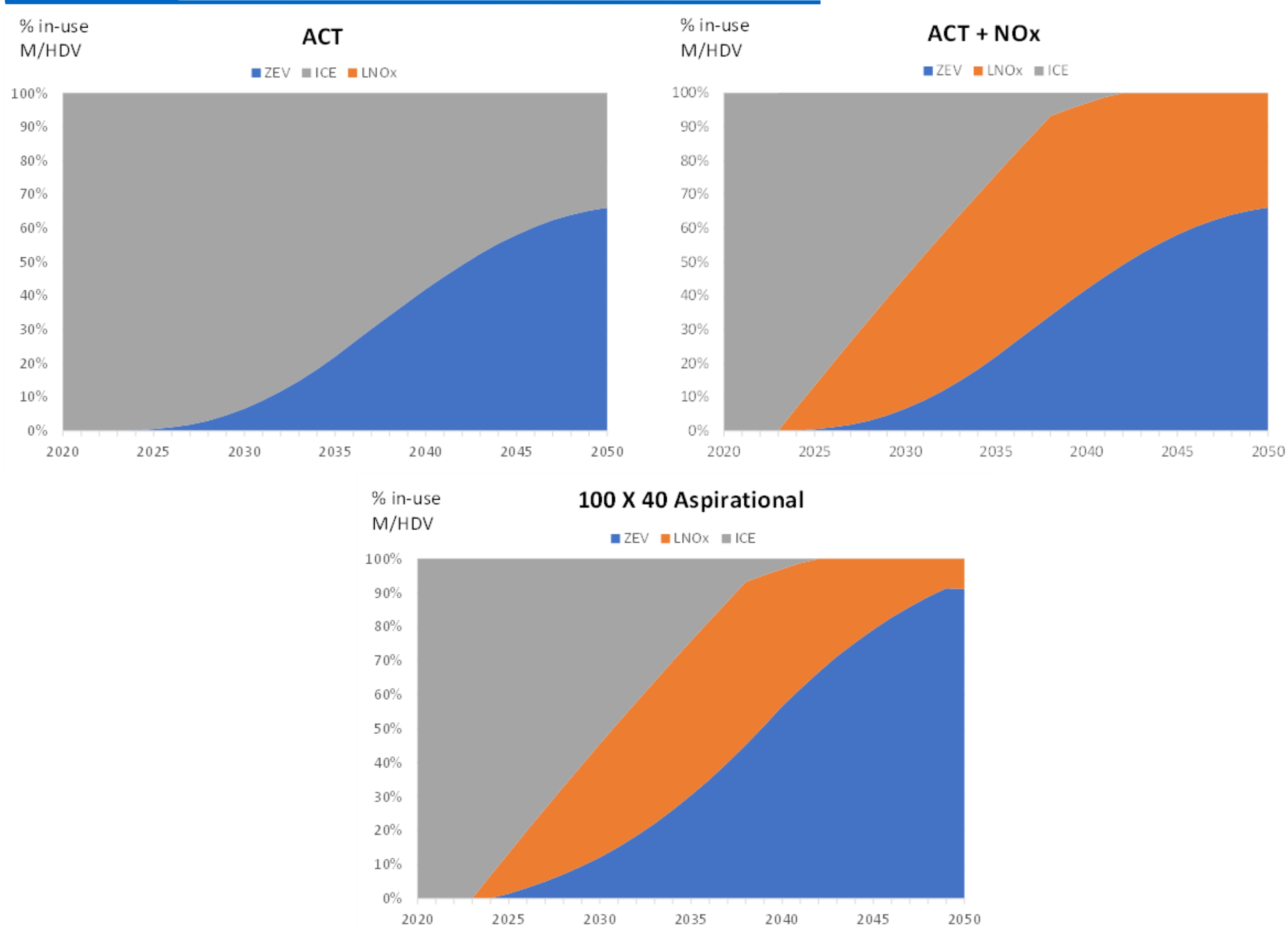
This analysis calculates average system-wide electricity generation costs based on projections by the EIA, but then adds incremental costs associated specifically with charging load under each scenario.

Statewide

ZEV Vehicles and Vehicle Miles Traveled

Figure 25, provides the relative percentages of the in-use M/HD fleet including ZEVs, low NOx vehicles and ICE vehicles for every year during the analysis period for the three different scenarios.

Figure 25 Projected % In-Use M/HD Vehicles in Colorado



As shown, the in-use fleet under the ACT scenario is made up with increasing ZEV vehicles, reaching 66 percent of the fleet by 2050. While under the ACT + NOx scenario, ZEVs contribution to the in-use fleet remains the same (66 percent), but layers in low NOx vehicles, meeting 100 percent of in-use vehicles in 2050. For the 100 X 40 Aspirational scenario, the percent of ZEV vehicles increases as you approach 2050, while the contribution of low NOx vehicles decreases, resulting in a 91 percent ZEV and 9 percent low NOx in-use fleet.

The projected number of ZEVs in the Colorado M/HD fleet under each scenario are shown in **Figure 26** and the projected annual miles driven by these vehicles are shown in **Figure 27**. [xxxvii]

Figure 26 Projected In-Use M/HD ZEVs in Colorado

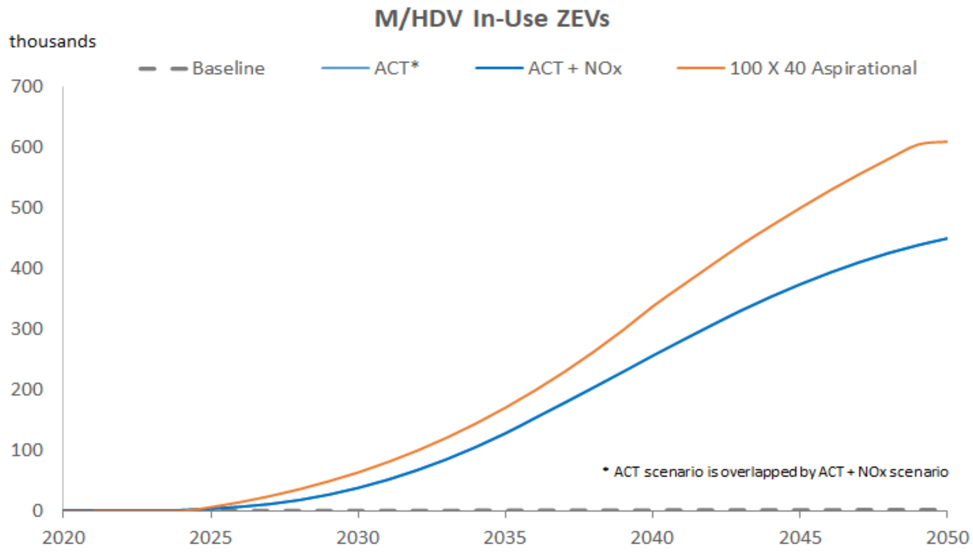
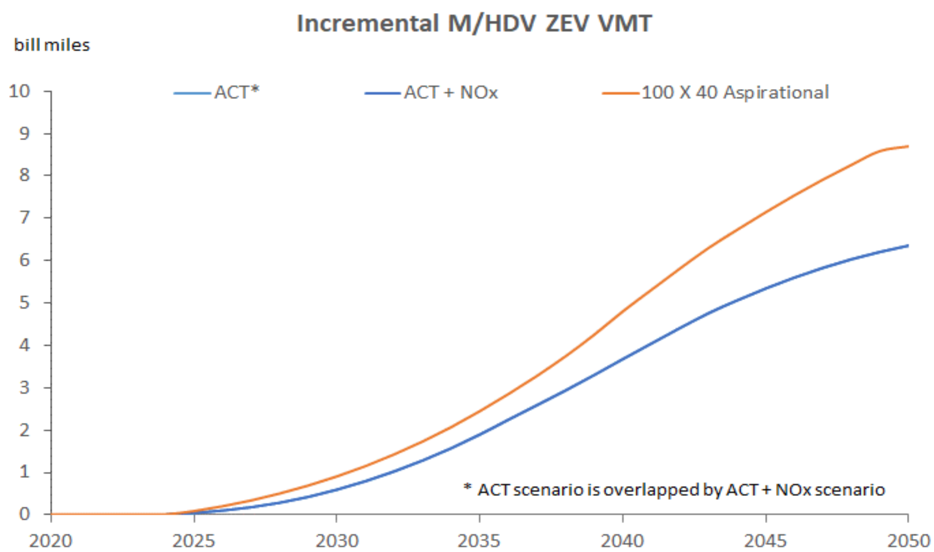


Figure 27 Estimated Total M/HD ZEV VMT (Billion Miles)



xxxvii This analysis only includes medium- or heavy-duty trucks and buses (Class 2b to 8). It does not include light duty passenger cars and trucks.

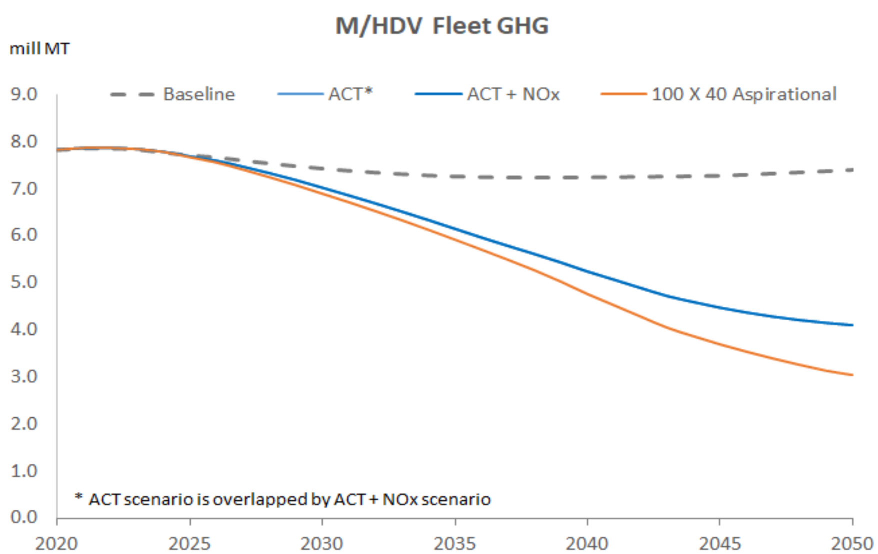
As shown under the ACT scenario (and the ACT + NOx scenario), there are projected to be nearly 451,000 ZEVs in Colorado by 2050 traveling 6.4 billion miles per year.[xxxviii] If Colorado adopts the ACT, and Heavy-Duty Low NOx Omnibus rules and enacts additional legislation (100 X 40 Aspirational), ZEV population steadily increases faster than the other ACT scenarios in the 2025-2045 timeframe, reaching over 609,000 vehicles by 2050, traveling 8.7 billion miles per year.

Emissions Savings

Based on penetration of ZEV vehicles in the M/HD fleet, the projected annual GHG emissions (million metric tons carbon-dioxide equivalent, CO_2e million tons) under each scenario are shown in **Figure 28**.

In this figure, projected baseline emissions from a gasoline and diesel fleet with few ZEVs are shown as a dashed gray line; while the different scenarios are shown as blue, or orange lines. The values shown represent "wells-to-wheels" emissions, including direct tailpipe emissions and "upstream" emissions from production and transport of different transportation fuels and electricity to charge ZEVs.

Figure 28 Estimated M/HD Vehicle Fleet GHG (Mill MT)



As shown in **Figure 28**, GHG emissions from the M/HD fleet were approximately 7.8 million metric tons in the near term under a baseline scenario but are projected to decline to 7.4 million metric tons in 2050. This projected reduction is based on turnover of the existing vehicle fleet to more efficient vehicles that meet more stringent fuel economy and GHG standards. Under the ACT and ACT + NOx scenarios, ZEVs are projected to reduce M/HD fleet GHG emissions by up to 0.4 million tons in 2030 and 3.3 million tons in 2050 compared to baseline emissions (-6 percent and -45 percent, respectively). For the 100 X 40 Aspirational scenario, GHG emissions are further reduced, resulting in 0.5 million tons reduced in 2030 (-7 percent) and 4.4 million tons reduced in 2050 compared to baseline emissions (-59 percent).

A medium- and heavy-duty fleet ZEV transition can also reduce net NOx and PM emissions from vehicles due to the switch from internal combustion engines used in conventional vehicles. Electric and hydrogen

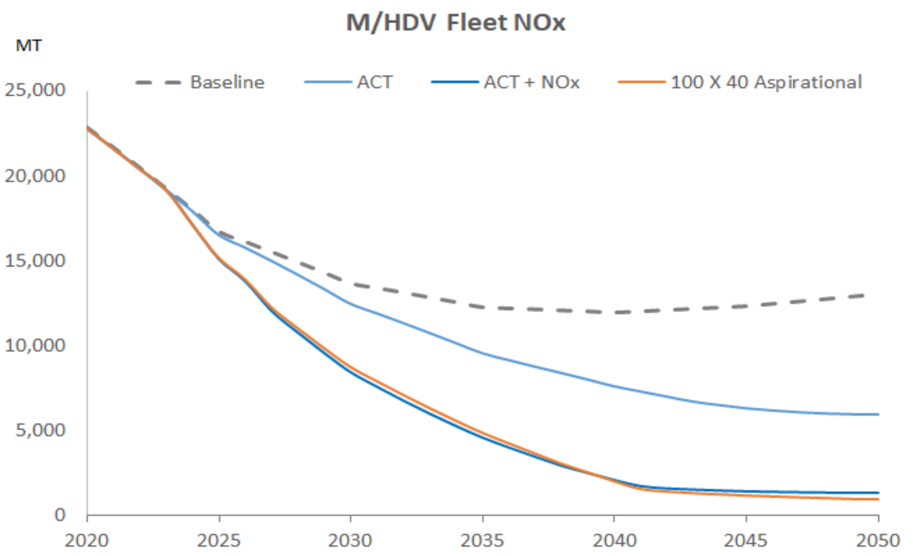
[xxxviii] Figure 25 illustrates that under these two scenarios, ZEVs will comprise approximately 60% of the M/HD fleet.

vehicles do not emit any tailpipe emissions; however, they are not necessarily zero emission vehicles and depending on the electricity grid mix, NOx and PM can be emitted when generating electricity for vehicle charging or if used for hydrogen production.

Under the scenarios which include the Heavy-Duty Low NOx Omnibus rule, sale of lower NOx vehicles with tailpipe reductions start in 2024 with a reduction of 75 percent in 2030 increasing to 90 percent approaching 2050.

Figures 29 and 30 illustrate the total fleet NOx and PM emissions for the different scenarios.

Figure 29 Estimated M/HD Vehicle Fleet NOx (MT)



Lifecycle NOx emissions from the M/HD fleet (**Figure 29**) are estimated to be more than 22,800 metric tons in the near term but will decline to about 13,000 metric tons in 2050, under the baseline scenario due to natural turnover to cleaner vehicles. Compared to the baseline, the ACT scenario will begin to deviate starting in 2025 as sales of ZEVs begin to increase and continue through 2050, resulting in a savings of over 7,000 metric tons in 2050 (-54 percent). Adding the Heavy-Duty Low NOx Omnibus Rule (ACT + NOx scenario), NOx emissions are further reduced beginning in 2025 and declining through 2050 due to the addition of Low-NOx truck sales in the state. Total reductions compared to baseline are almost 12,000 metric tons in 2050 (-90 percent). Further building on the ACT and Heavy-Duty Low NOx Omnibus Rule with complementary actions (100 X 40 Aspirational), NOx emissions will decline quickly after 2030 as more ZEVs enter the Colorado fleet, driving down emissions to just over 900 metric tons in 2050 (12,100 metric tons – 93 percent – reduction compared to baseline).

Lifecycle PM emissions (**Figure 30**) for the scenarios follow the baseline trajectory closely until 2030 as the electric grid continues to decarbonize, coupled with ZEV sales increasing. For the ACT and ACT + NOx scenarios, the analysis projects a 111 metric ton reduction compared to the baseline in 2050 (-53 percent). Under the 100 X 40 Aspirational scenario, PM emissions begin to decline quickly after 2030, providing a savings of over 140 metric tons compared to the baseline in 2050 (-68 percent).

Figure 30 Estimated M/HD Vehicle Fleet PM (MT)

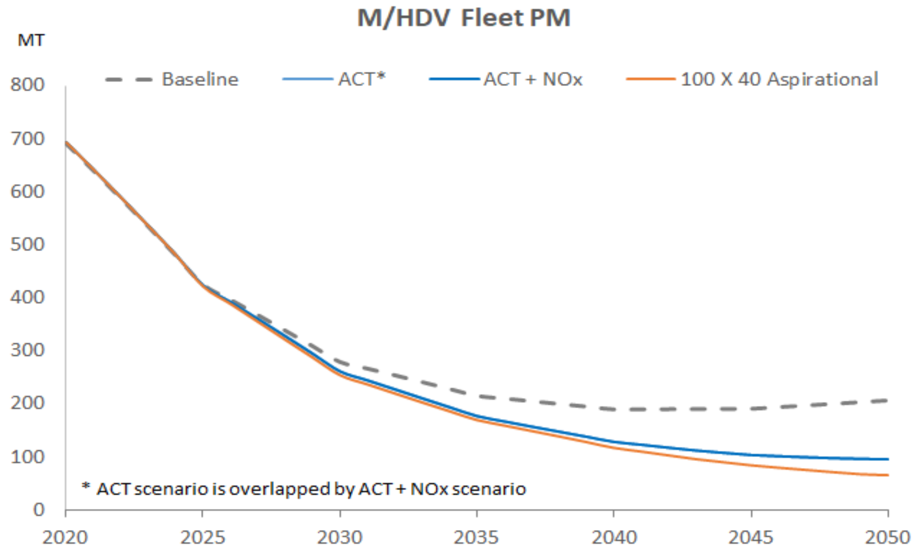
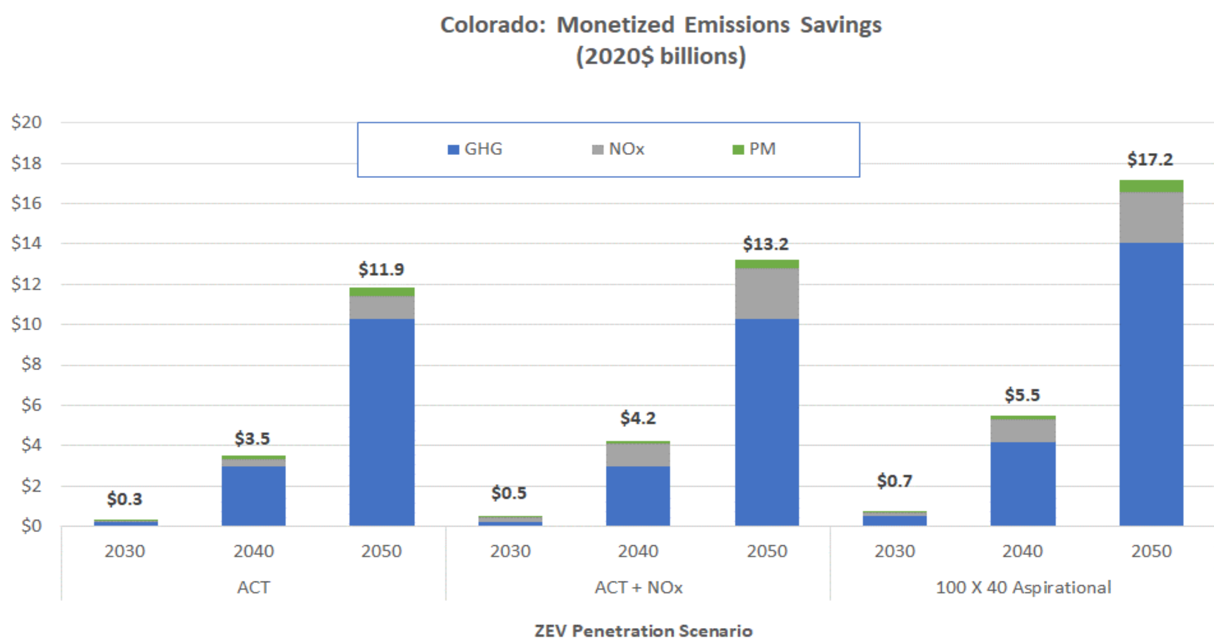


Figure 31 summarizes the projected cumulative monetized "social value" of GHG, NOx and PM reductions that will result from the different scenarios, compared to the baseline. The social value of GHG reductions represent potential cost savings from avoiding the negative effects of climate change (e.g., rising sea levels, global temperature rise, etc.), if GHG emissions are reduced enough to keep long-term warming below two degrees Celsius from pre-industrial levels. The NOx and PM values represent the monetized health effects of reduced air pollution and their effect on hospital and emergency room visits. The GHG values summarized in **Figure 31** were developed using the Social Cost of CO_2, CH_4 and N_2O (2020$/MT) as calculated by the U.S. government's Interagency Working Group on Social Cost of Greenhouse Gases (2016 update), while values for NOx and PM were obtained from EPA's COBRA model specifically for Colorado.

Figure 31 Projected Social Value of GHG, NOx, and PM Reductions (2020$ billion)

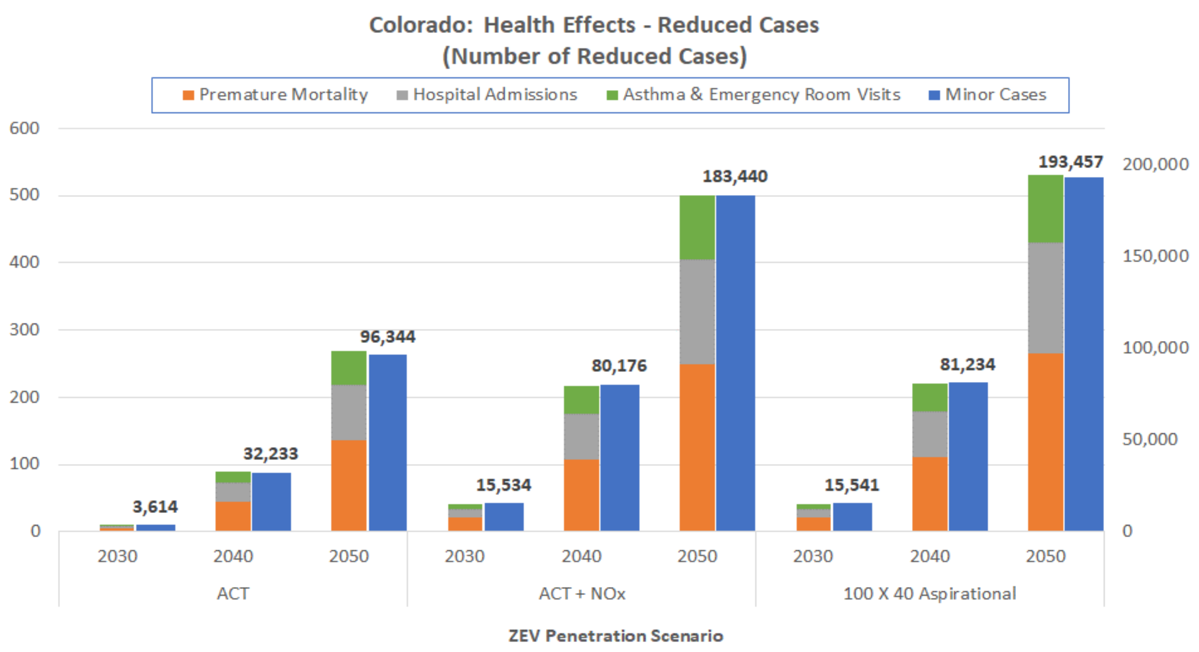


The monetized social value of cumulative GHG, NOx and PM reductions resulting from each of the scenarios is projected to range from \$11.8 billion in 2050 for the ACT scenario to \$17.1 billion for the 100 X 40 Aspirational scenario. The majority of the social benefit comes from GHG reductions (blue bars), but under scenarios that include the Heavy-Duty Low NOx Omnibus Rule, social values for monetized NOx benefits (gray bars) are significantly higher than the scenarios without them.

Health Effects

Reductions in NOx and PM emissions can help improve air quality for the local area and contribute to reduced asthma and other emission-related health problems for individuals living in the area. Using EPA's COBRA model, health effect values for premature mortality, hospital admissions, asthma and emergency room visits, as well as minor health-related cases were modeled for Colorado. Values from the COBRA model are provided as the number of cases per metric ton of reduction (#/MT). See **Figure 32**, for the cumulative emission health effects in 2050 for each of the four scenarios, compared against the baseline. Note, Minor Cases (blue bars) use the scale on the right side of the chart, while other health effects are shown using the left scale.

Figure 32 Projected Health Effects 2050



As shown in the figure, reduced emissions have a large effect on minor cases, totaling over 96,300 reduced cases in 2050 under the ACT scenario, while the 100 X 40 Aspirational scenario totals nearly 195,000 reduced cases in 2050. Reductions in NOx and PM will also help reduce premature mortality, with between 135 cases reduced under the ACT scenario to 265 cases under the 100 X 40 Aspirational scenario in 2050.

Denver Metro Region and the North Front Range

The results from the statewide STEP tool analysis were apportioned to obtain benefits and costs to the Denver Metro region as well as the North Front Range metropolitan planning area using county-specific VMT estimates from EPA's Motor Vehicle Emission Simulator (MOVES). Using county-level VMT data for Denver, Arapahoe, Jefferson, Adams, Douglas, Broomfield, Elbert, Park, Clear Creek and Gilpin counties, an apportionment was derived for Denver Metro. Similarly, for the North Front Range, an apportionment was performed using portions of Larimer and Weld counties in Northern Colorado. Based on the apportionment analysis, Denver Metro represents 62.8 percent of the state-wide results, while the North Front Range equals approximately 8.3 percent of the state. The following section describes the emission benefits and health impacts of ZEV and low NOx vehicle penetration to these areas.

ZEV Vehicles and Vehicle Miles Traveled (VMT)

The MOVES model tabulates VMT on a county-level basis. The Denver metro region comprises ten contiguous cities and counties: Denver, Arapahoe, Jefferson, Adams, Douglas, Broomfield, Elbert, Park, Clear Creek, and Gilpin.[xxxix] The sum of VMT in these counties are aggregated and assigned as the average VMT for a vehicle in the Denver metro region. The combined population of the region is approximately 63 percent of the state's population, which is consistent with the share of Urban versus Rural VMT calculations provided by the Federal Highway Administration.

The North Front Range Metropolitan Planning Organization (NFRMPO) consists of portions of Larimer and Weld Counties, including Fort Collins. Because the MPO is a portion of two counties, it must be split by population. The NFRMPO's population is approximately 480,000 compared to the combined population of Weld and Larimer Counties of 682,000. This 70 percent of population residing within the MPO will be assigned the corresponding 70 percent of VMT tabulated by MOVES.

Based on the three state-wide modeling scenarios, the projected number of ZEVs in the Denver Metro M/HD fleet under each scenario are shown in **Figure 33** and the projected annual miles driven by these vehicles are shown in **Figure 34**. **Figure 35** and **Figure 36** show the projected number of ZEVs and their VMT for the North Front Range. As shown in **Figure 33**, ZEV vehicles under the ACT scenario (and the ACT + NOx scenario) are projected to be nearly 284,000 ZEVs in Denver Metro by 2050 traveling 4.0 billion miles per year. If Colorado adopts the ACT, Heavy-Duty Low NOx Omnibus rules and enacts additional legislation (100 X 40 Aspirational), ZEV population in Denver Metro steadily increases faster than the other scenarios in the 2025-2045 timeframe, reaching over 380,000 vehicles by 2050, traveling 5.4 billion miles per year.

[xxxix] The Denver Metropolitan Area was defined as the U.S. Office of Management and Budget Denver-Aurora-Lakewood Metropolitan Statistical Area and differs from that used for the CO Inspection/Maintenance program.

Figure 33 Denver Metro: M/HDV In-Use ZEVs

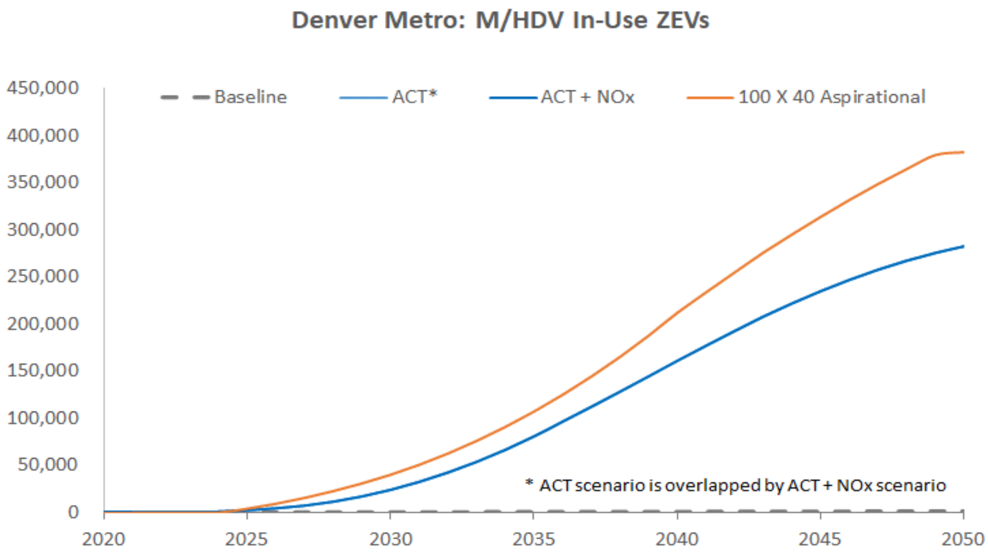


Figure 34 Denver Metro: Incremental M/HDV ZEV VMT

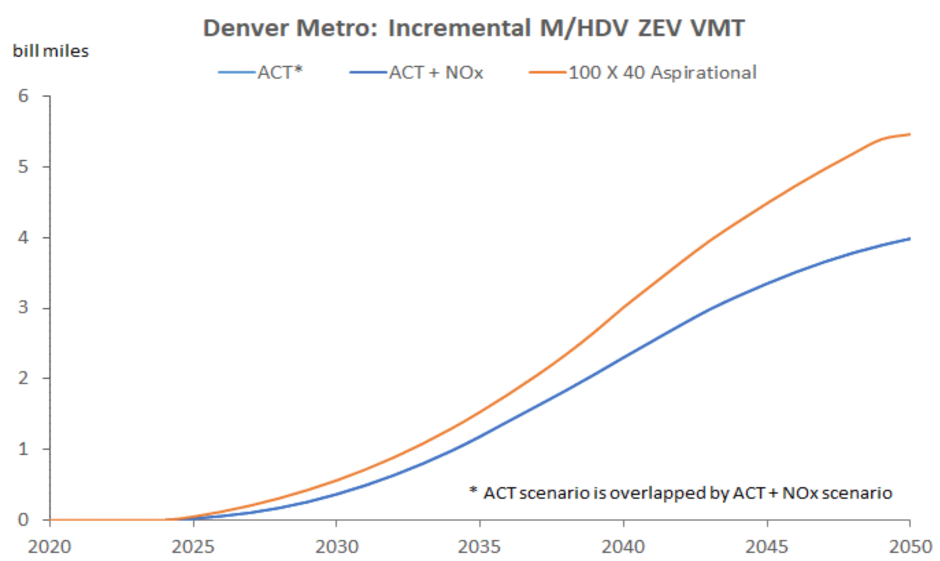


Figure 35 Projected In-Use ZEVs in North Front Range

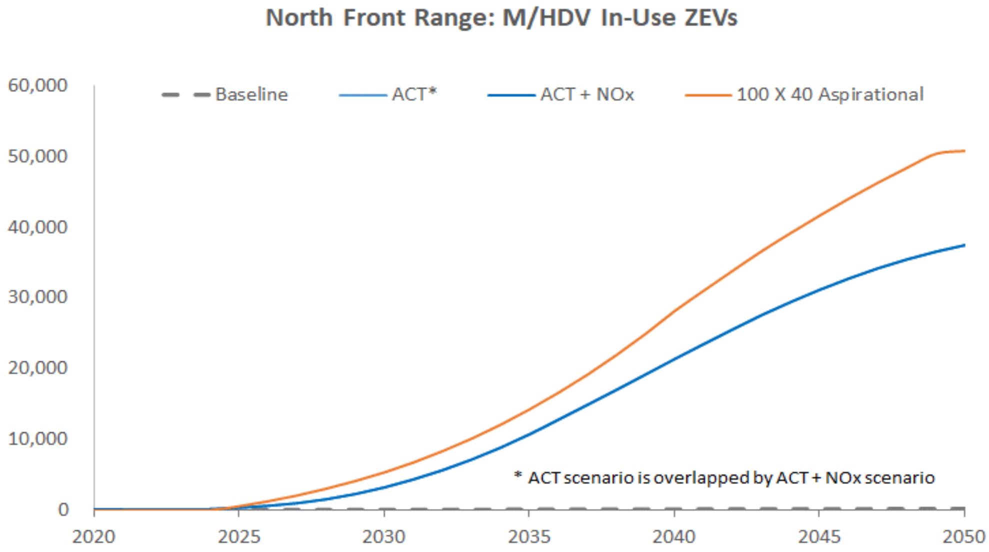
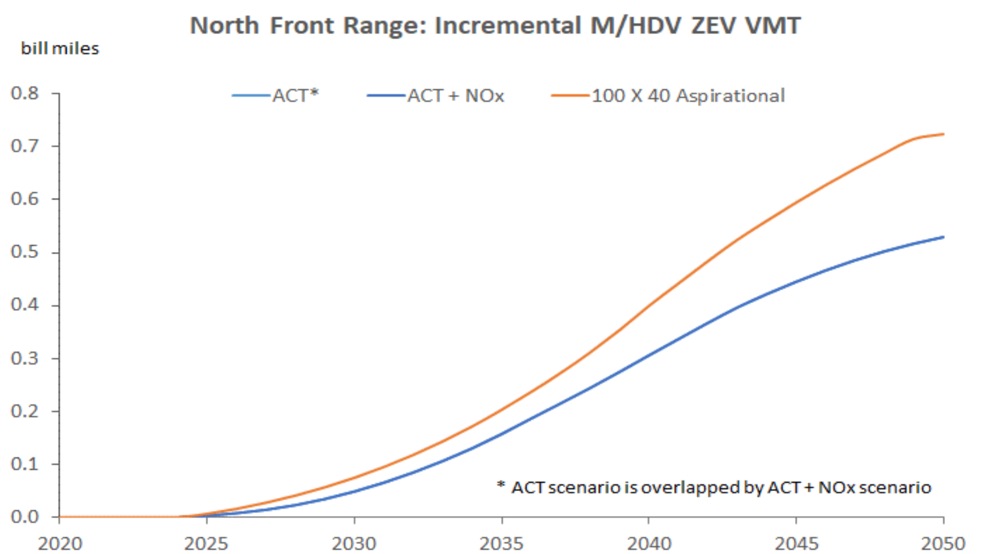


Figure 36 Estimated Total ZEV VMT in North Front Range



Figures 35 and 36 illustrate the projected ZEV population and annual VMT in the North Front Range area under the ACT scenario (and the ACT + NOx scenario) at nearly 37,500 ZEVs by 2050, traveling 530 million miles annually. For the 100 X 40 Aspirational scenario, ZEV penetration continues an upward trend, reaching nearly 51,000 vehicles by 2050, all traveling 725 million miles annually.

GHG *Emissions Savings*

Based on ZEV vehicle penetration in the Denver Metro and North Front Range M/HD fleets, the projected annual GHG emissions (million metric tons carbon-dioxide equivalent, CO_2e million tons) under each scenario are shown in the following figures (**Figure 37** and **Figure 38**).

Figure 37 Denver Metro: M/HDV Fleet GHG

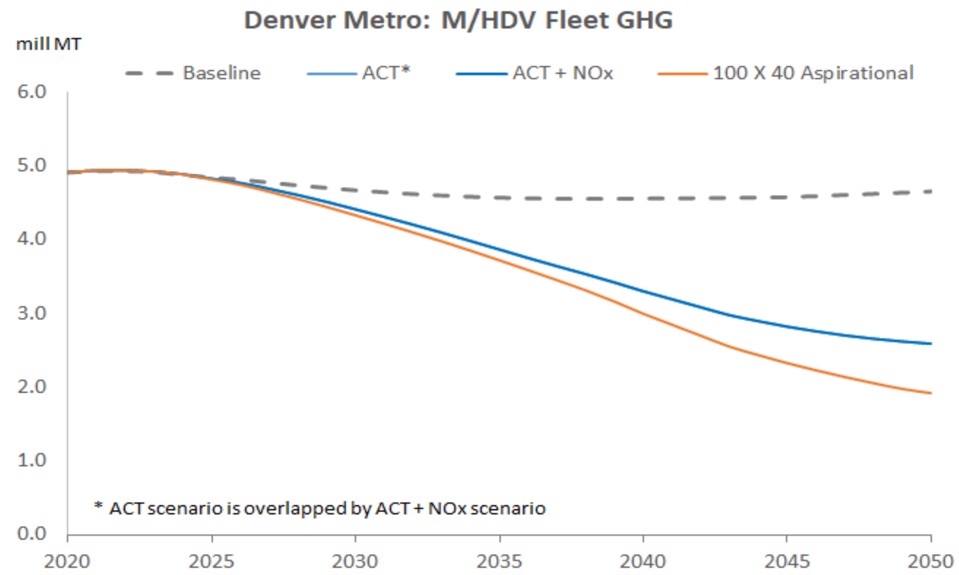
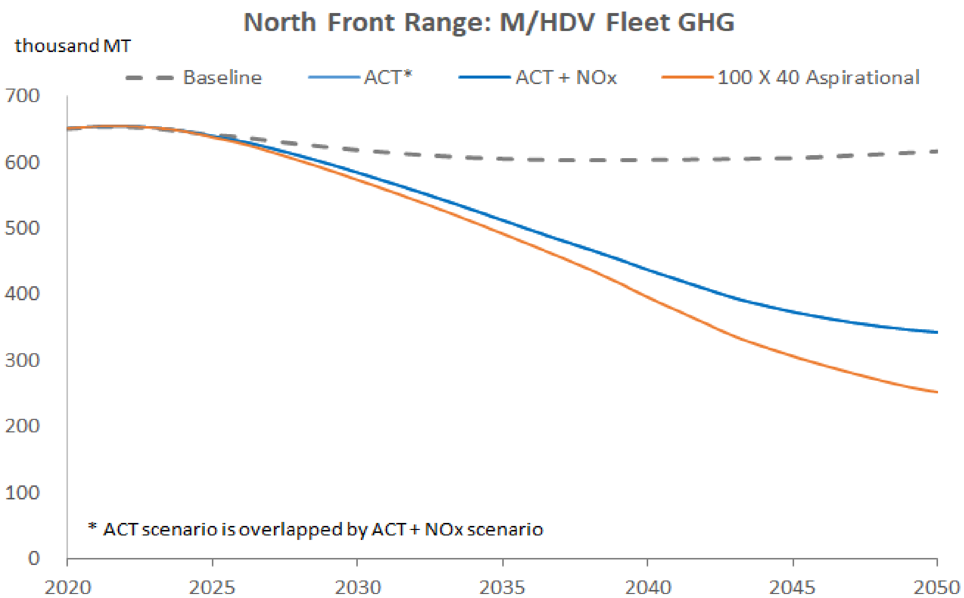


Figure 38 North Front Range: M/HDV Fleet GHG



GHG emissions from the Denver Metro M/HD fleet (**Figure 37**) were approximately 4.9 million metric tons in 2020 under a baseline scenario but are projected to decline to 4.7 million metric tons in 2050. Under the ACT and ACT + NOx scenarios, ZEVs are projected to reduce M/HD fleet emissions by up to 2.1 million tons in 2050 compared to baseline emissions (-45 percent). For the 100 X 40 Aspirational scenario, GHG emissions are further reduced, reaching 2.8 million tons of reductions in 2050 compared to baseline emissions (-59 percent).

For the North Front Range (**Figure 38**) under the ACT and ACT + NOx scenarios, ZEVs are projected to reduce M/HD fleet GHG emissions by nearly 0.3 million tons in 2050 (-45 percent). Emission savings are projected to be nearly 0.4 million tons under the 100 X 40 Aspirational scenario (-59 percent).

For NOx and PM emissions, the Denver Metro and North Front Range areas could see significant reductions from the sale of ZEV and low NOx vehicles. See **Figures 39 and 40** for the scenario trajectories for NOx, and **Figures 41 and 42** show the PM levels under the different scenarios.

NOx reductions for the Denver Metro area (**Figure 39**) could range from 4,400 metric tons under the ACT scenario to 7,600 metric tons under the 100 X 40 Aspirational scenario in 2050. Comparing PM emissions (**Figure 41**) for the different scenarios in the Denver Metro area, reductions could range from 69 (ACT) to 89 metric tons (100 X 40 Aspirational scenario) in 2050.

Figure 39 Denver Metro: M/HDV Fleet NOx

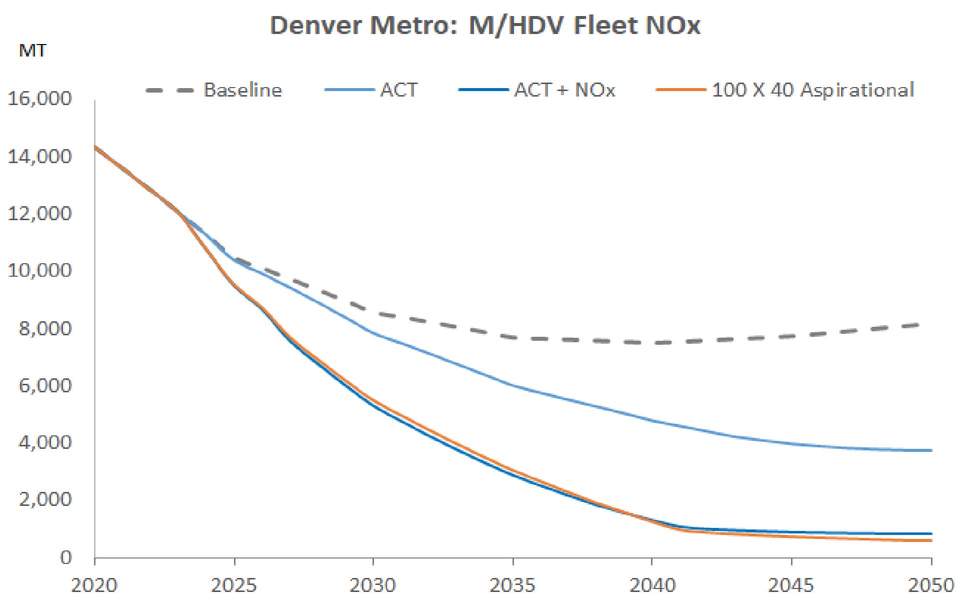
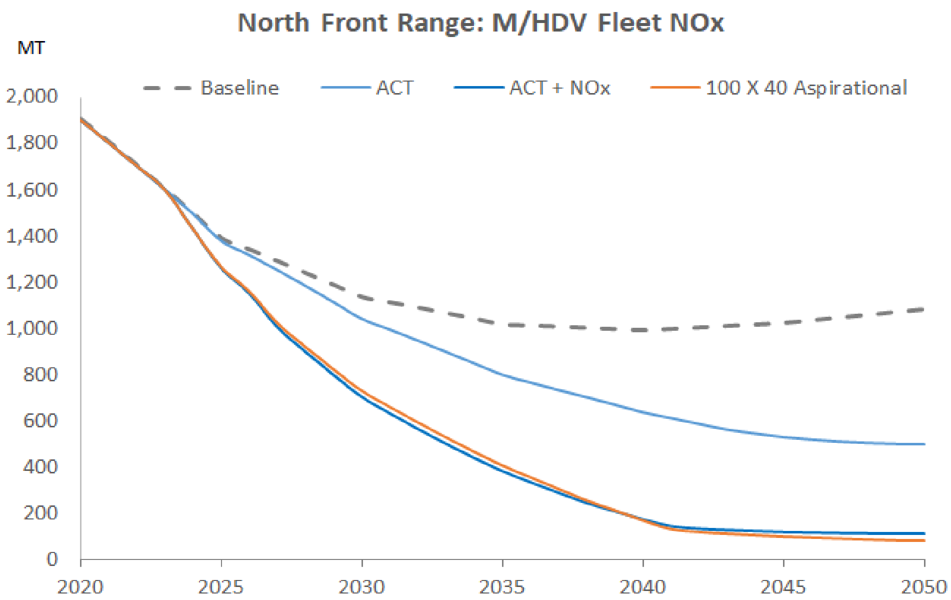


Figure 40 North Front Range: M/HDV Fleet NOx



For the North Front Range, NOx reductions (**Figure 40**) could range from 588 metric tons under the ACT scenario to 1,009 metric tons under the 100 X 40 Aspirational scenario by 2050. PM emissions for the individual scenarios in the North Front Range area (**Figure 42)** could range from 9 metric ton reduction under the ACT scenario to 12 metric tons of reduction following the ZEV penetration trajectory of the 100 X 40 Aspirational scenario by 2050.

Figure 41 Denver Metro: M/HDV Fleet PM

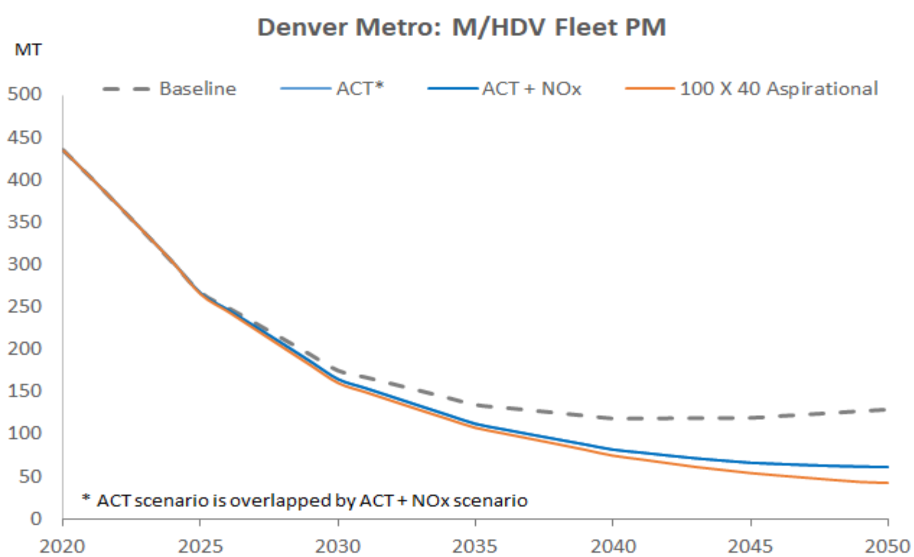
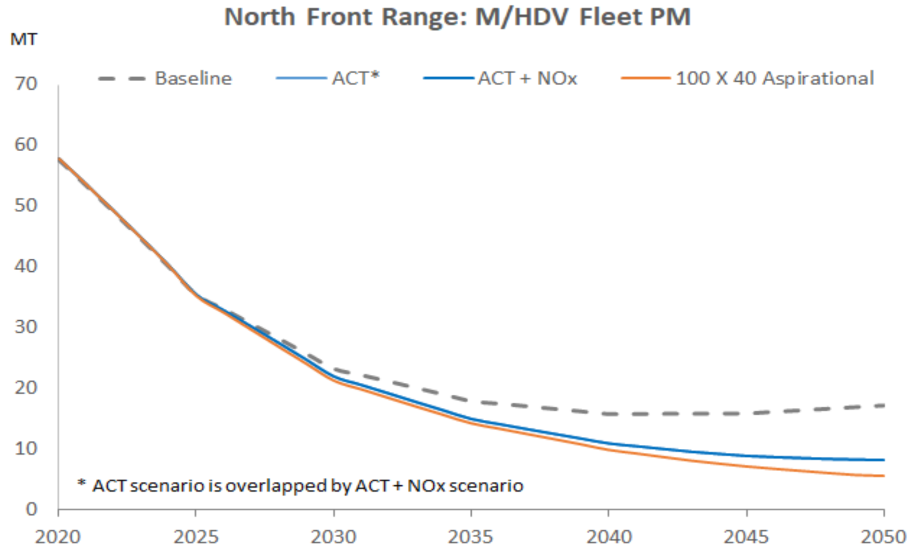
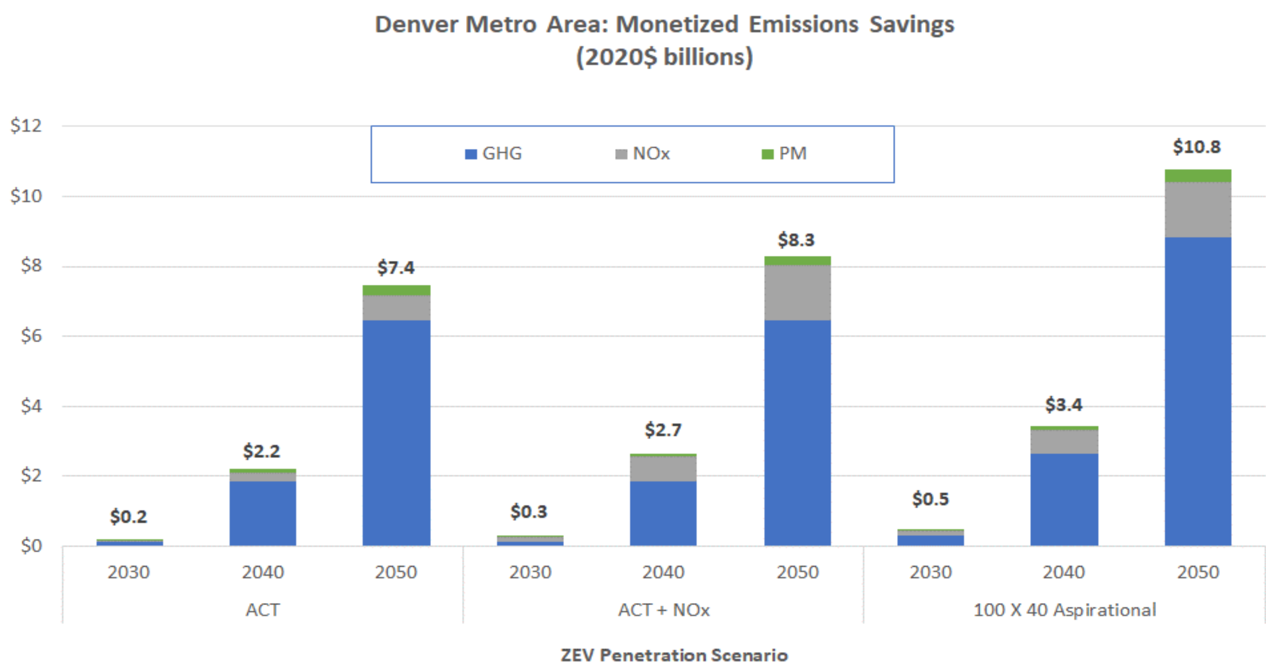


Figure 42 North Front Range: M/HDV Fleet PM



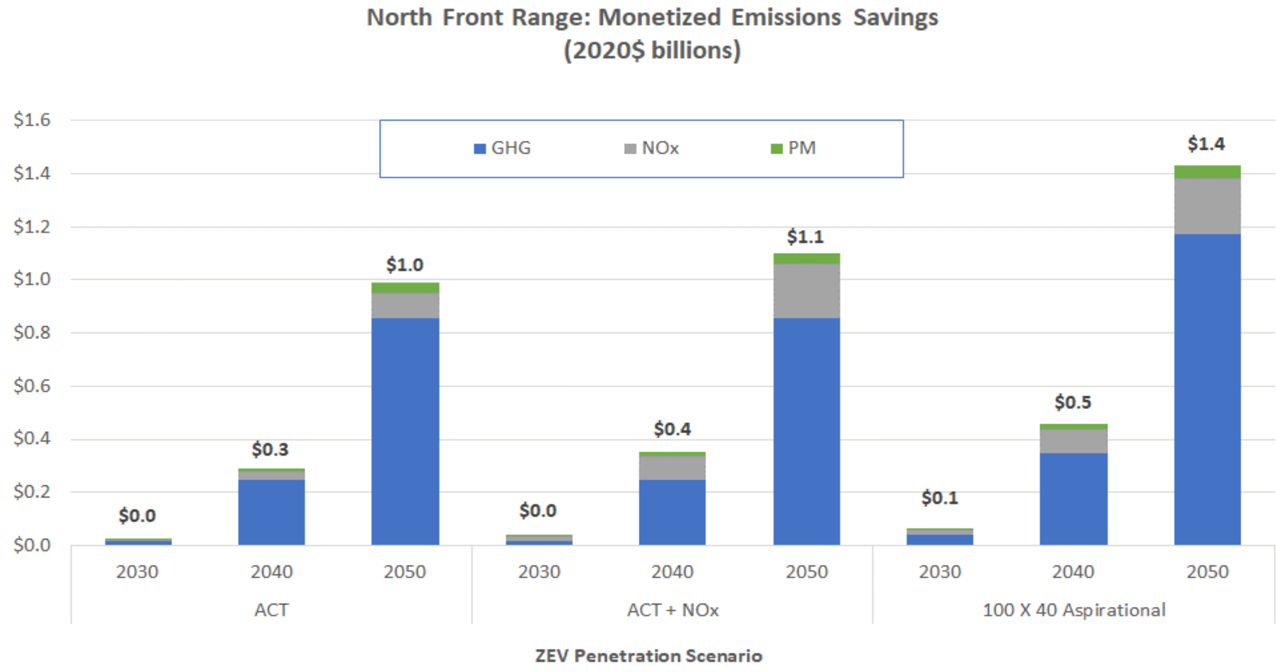
Figures 43 and 44 summarize the projected cumulative monetized "social value" of GHG, NOx and PM reductions that will result from the different scenarios, for the Denver Metro and North Front Range areas.

Figure 43 Denver Metro Projected Social Value of GHG, NOx, and PM Reductions (2020$ billion)



The monetized social value of cumulative GHG, NOx and PM reductions resulting from each of the scenarios is projected to range from $ 7.4 billion in 2050 for the ACT scenario to $10.8. billion for the 100 X 40 Aspirational scenario in the Denver Metro Area.

Figure 44 North Front Range Projected Social Value of GHG, NOx, and PM Reductions (2020$ billion)



The monetized social value of cumulative GHG, NOx and PM reductions resulting from each of the scenarios is projected to range from $ 1.0 billion in 2050 for the ACT scenario to $1.4 billion for the 100 X 40 Aspirational scenario in the North Front Range.

Health Effects

Reductions of NOx and PM emissions can help improve air quality for the Denver Metro and North Front Range areas and contribute to reduced emission-related health problems for individuals living in these areas. Using EPA's COBRA model, health effect values for premature mortality, hospital admissions, asthma and emergency room visits, as well as minor health-related cases were modeled for the Denver Metro and North Front Range areas. Values from the COBRA model are provided as the number of cases per metric ton of reduction (#/MT). See **Figures 45 and 46**, for the cumulative emission health effects in 2050 for each of the four scenarios, compared against the baseline. Note, Minor Cases (blue bars) use the scale on the right side of the chart, while other health effects are shown using the left scale.

Figure 45 Denver Metro Projected Health Effects in 2050

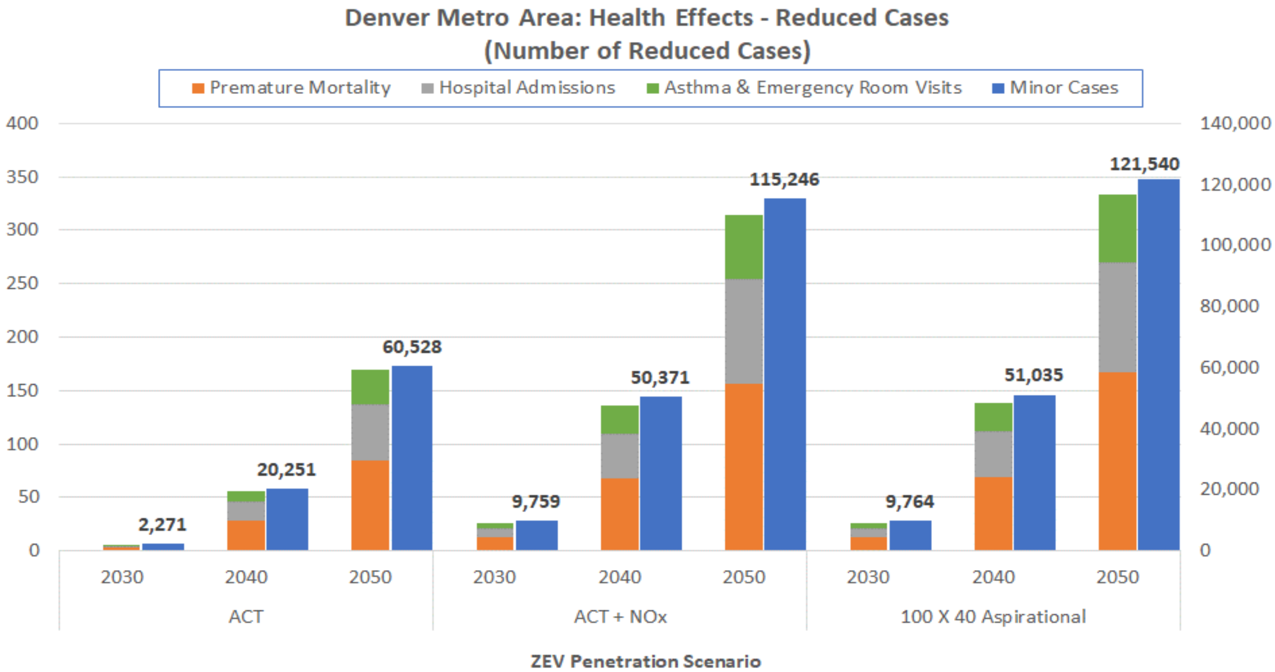
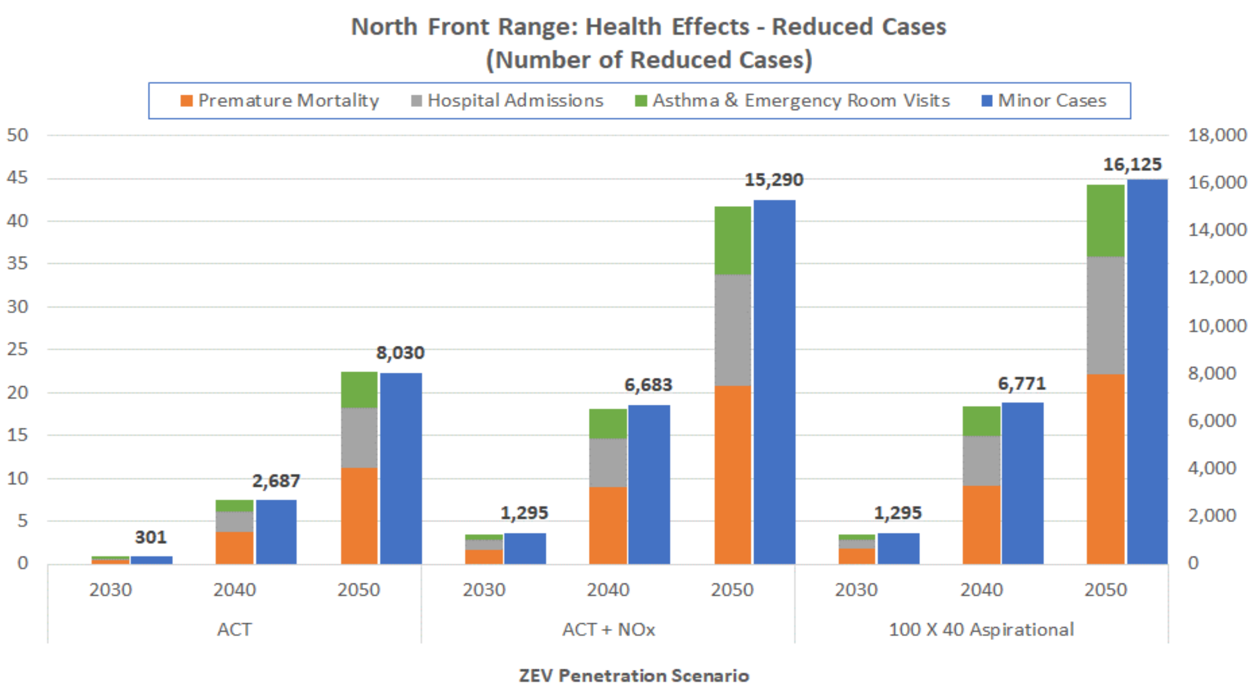


Figure 46 North Front Range Projected Health Effects in 2050



In the Denver Metro figure, reduced emissions are predicted to have a large effect on minor cases by 2050 – nearly 62,000 reduced cases under the ACT scenario, and almost 122,000 reduced cases for the 100 X 40 Aspirational scenario. Reductions in NOx and PM will also help reduce premature mortality, with estimates of 85 and 167 cases reduced under the ACT and the 100 X 40 Aspirational scenarios, respectively.

Looking at the North Front Range area (**Figure 46**), minor cases could total more than 8,000 reduced cases in 2050 under the ACT scenario. Continuing ZEV penetration and Low-NOx vehicles under the 100 X 40 Aspirational scenario, total reduction in minor cases could be as high as 16,125 reduced cases in 2050. Reduced premature mortality in the North Front Range varies from 11 cases under the ACT rule to 22 cases under the 100 X 40 Aspirational scenario.

Vehicle and Infrastructure Net Costs

M/HD ZEV vehicles are projected to be more expensive to purchase than similar sized gasoline and diesel trucks, with upfront cost parity not taking place for all vehicle types until after the 2050 analysis horizon. These vehicles will also require capital investments for purchase, installation and maintenance of charging or refueling infrastructure to refuel these battery-electric or hydrogen fuel cell vehicles. These costs are offset by reduced vehicle maintenance for ZEV vehicles as well as significant fuel cost savings from the switch to lower-cost electricity.

Table 11 presents the predicted costs and savings, averaged across the analysis timeframe, associated with vehicle purchases, their infrastructure, as well as the fuel cost savings, reduced maintenance savings and charger operations and maintenance. These values are totaled to calculate the Net Financial Cost associated with each scenario. Values have been provided in constant 2020$ millions as well as nominal$ millions.[xl] Further detailed tables for each scenario during individual decades have been provided in Appendix III.

The total net financial costs for the ZEV transition (total from 2021 to 2050) under each scenario are negative, meaning that the projected fuel and maintenance savings will outweigh the costs associated with vehicle purchase and their infrastructure. When looking at the individual decades (i.e., 2021-2030, 2031-2040, and 2041 to 2050), net financial costs are positive (i.e., an additional cost to the adopter as compared to an ICE vehicle) in the 2021-2030 timeframe due to higher purchase costs for M/HD ZEVs. As the incremental purchase price of vehicles begins to fall in the 2030-2035 timeframe, the net financial costs become negative and provide savings to ZEV owners. Further detail is provided in Appendix III.

Table 11 illustrates that while initial ZEV costs are greater than conventional gasoline and diesel vehicles (Incr ZEV Purchase), the lower fuel and maintenance costs (Net Fuel Costs, Incr Veh. Maintenance) outweigh the initial incremental costs, resulting in net financial savings of approximately $5.8 billion under the ACT + NOx scenario to $8.3 billion under the 100 X 40 Aspirational scenario (2020$) in 2050. These savings will be in the form of reduced fuel and maintenance costs to Colorado vehicle owners.

On average across the 30-year analysis period, the ACT and ACT + NOx scenarios project incremental purchase costs of nearly $2,180 per M/HD ZEV, while the 100 X 40 Aspirational scenarios project costs closer to $2,800 per ZEV. For ZEV infrastructure, costs per ZEV range from $3,926 to $5,191 per vehicle over the analysis timeframe. Average costs vary due to differences in assumptions about ZEV adoption in each vehicle class between scenarios.

[xl] Table 11 provides the total financial costs of each scenario over the analysis timeframe (2021-2050). Fuel and maintenance savings are for vehicles operating during the analysis period and not over each vehicle's lifetime.

Fuel savings per ZEV on an average annual basis show that both the ACT and ACT + NOx scenarios each provide nearly $850 in reduced fuel cost per ZEV per year, while the 100 X 40 Aspirational provides even greater savings of more than $1,200 per ZEV per year (2021-2050).

Similarly, with respect to maintenance, ZEVs will help save vehicle owners money by reducing the maintenance costs annually, ranging from $807 per ZEV to $1,111 per ZEV per year.

Table 11 Total Net Financial Costs Over the Analysis Horizon (2021 to 2050)

			ACT	ACT + NOx	100 X 40 Aspirational
Incr ZEV Purchase		2020$ mill	$1,168	$1,168	$2,142
		nom$ mill	*$1,619*	*$1,619*	*$2,843*
Incr Low-NOx ICE Purchase		2020$ mill	$0	$1,213	$689
		nom$ mill	*$0*	*$1,708*	*$883*
Charging Infrastructure	**Purchase**	2020$ mill	$1,403	$1,403	$2,315
		nom$ mill	*$2,183*	*$2,183*	*$3,602*
	Install	2020$ mill	$702	$702	$1,174
		nom$ mill	*$1,098*	*$1,098*	*$1,837*
Petroleum Fuels		2020$ mill	($15,655)	($15,655)	($20,761)
Electricity		2020$ mill	$9,958	$9,958	$11,387
Hydrogen		2020$ mill	$0	$0	$1,086
NET FUEL COST		2020$ mill	($5,697)	($5,697)	($8,287)
		nom$ mill	*($9,456)*	*($9,456)*	*($13,780)*
Incr Veh Maintenance		2020$ mill	($5,500)	($5,499)	($7,568)
		nom$ mill	*($9,116)*	*($9,115)*	*($12,509)*
Charger Operations & Maintenance		2020$ mill	$954	$954	$1,189
		nom$ mill	*$1,566*	*$1,566*	*$1,945*
NET FINANCIAL COST		2020$ mill	**($6,969)**	**($5,756)**	**($8,345)**
		nom$ mill	***($12,107)***	***($10,398)***	***($15,180)***
Incr ZEV Purchases		mill	*0.54*	*0.54*	*0.76*
AVG Incr In-use ZEV		mill	*0.227*	*0.23*	*0.227*
AVG Incr Purchase Cost		2020 $/ZEV	$2,178	$2,178	$2,800
AVG Charging Infra Cost		2020 $/ZEV	$3,926	$3,926	$4,562
AVG Annual Fuel Cost Sav		2020 $/ZEV	($836)	($836)	($1,216)
AVG Annual Maint Cost Sav		2020 $/ZEV	($807)	($807)	($1,111)

Tables 12, and 13 present a closer look at the average values from Table 11 and illustrate the projected life cycle costs for a M/HD vehicle over its life for different model years of vehicles.[xli]

Table 12 M/HD Lifecycle Costs – ACT and ACT + NOx Scenarios

AVG 2020$		MY2025	MY2030	MY2035	MY2040
Per New ZEV	Incr Vehicle Purchase	$21,400	$5,074	$2,051	$1,532
	Chargers	$4,498	$4,313	$4,035	$3,827
Per In-use ZEV Discounted Life-time	Net Fuel Cost	$4,112	($15,587)	($15,378)	($15,441)
	Incr Veh Maintenance	($13,984)	($14,262)	($14,978)	($15,056)
	Charger Maint	$6,659	$3,734	$2,564	$2,459
NET LIFE CYCLE COSTS		**$22,685**	**($16,728)**	**($21,705)**	**($22,678)**
NET OPTG COSTS		($3,213)	($26,116)	($27,792)	($28,038)

Table 13 M/HD Lifecycle Costs – 100 X 40 Aspirational Scenario

AVG 2020$		MY2025	MY2030	MY2035	MY2040
Per New ZEV	Incr Vehicle Purchase	$25,693	$6,873	$2,487	$1,520
	Chargers	$5,493	$5,245	$4,729	$4,407
Per In-use ZEV Discounted Life-time	Net Fuel Cost	($8,870)	($14,575)	($16,183)	($17,208)
	Incr Veh Maintenance	($13,567)	($14,420)	($15,108)	($15,119)
	Charger Maint	$3,378	$3,018	$2,378	$2,207
NET LIFE CYCLE COSTS		**$12,126**	**($13,858)**	**($21,698)**	**($24,193)**
NET OPTG COSTS		($19,060)	($25,977)	($28,913)	($30,119)

As shown, model year 2025 (MY2025) vehicles under the different scenarios will incur lifecycle costs greater than ICE vehicles ranging from $12,126 to $22,685 per vehicle. A contributing factor to this is the assumption that electricity pricing ($/kWh) is increasing above 2020 levels in the early years of the analysis faster than the cost of gasoline and diesel fuel. Beyond 2025, these projections shift, increasing prices for gasoline and diesel fuel, while electricity pricing is projected to decline 16 percent through 2050.[xlii] For MY2030 and beyond, the incremental vehicle purchase price decreases, and savings associated with reduced fuel use and maintenance increase, resulting in life cycle savings for the vehicle owner. By MY2040, the different scenarios project average ZEV savings to their owner of $22,678 to $24,193 over the vehicle's life.

Charging Load and Utility Impacts

This analysis evaluated the effect of electric vehicle charging on the Colorado electric grid and how the net revenue from vehicle charging could increase the net revenue realized by Colorado's electric utilities, which could help lower costs for ratepayers. See **Table 14** for a comparison of Projected Incremental Afternoon Peak Hour ZEV Charging Load (MW) for each of the scenarios.

[xli] For this analysis, a M/HD vehicle is assumed to have a 21-year lifetime, based on MJB&A analysis of the 2020 Transportation Energy Data book, produced by the Federal Highway Administration. Fuel and maintenance costs have been discounted at 4% over the life of the vehicle.
[xlii] Based on projections by EIA as part of their Annual Energy Outlook 2021 Reference case

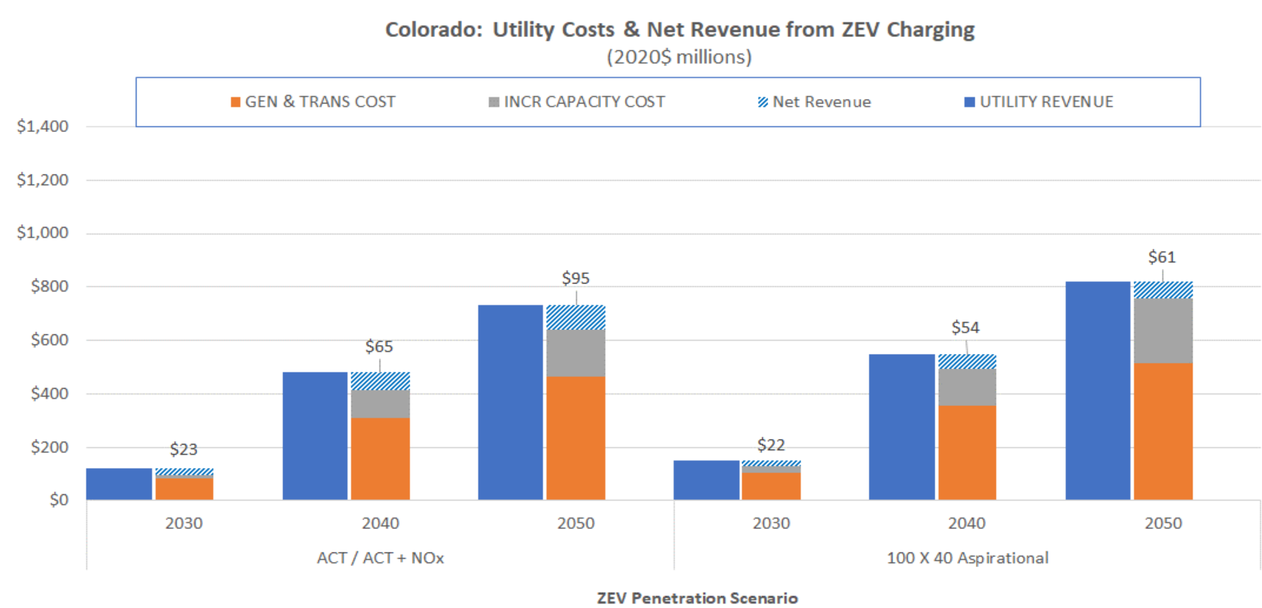
Table 14 ZEV Charging Load by Scenario

	ACT / ACT + NOx			100 X 40 Aspirational		
	2030	2040	2050	2030	2040	2050
ZEV Charging (MW)	168.9	1,170.4	2,056.5	297.8	1,560.4	2,815.2

Table 14 shows that charging will increase peak hour load under the ACT and ACT + NOx scenarios by almost 170 MW in 2030, increasing to nearly 2,100 MW in 2050. Under the 100 X 40 Aspirational scenario, peak hour load is projected to increase by almost 300 MW in 2030, rising to more than 2,800 MW in 2050. It should be noted that this analysis assumes a significant portion of M/HD ZEV vehicles will plug in and charge overnight, reducing peak charging demand during the day. Eighty percent of buses, 90 percent of single-unit trucks, and 30 percent of combination trucks are assumed to use overnight depot-based charging, with 9–11 hours per day available for charging. Individual depot chargers will need to be capable of charging at 10 kW to 50kW for different vehicle types according to daily energy use and available charge time. The remainder of vehicles are assumed to be charged at higher-capacity (100–600 kW) shared public chargers, with only 2 hours/day/vehicle available for charging.

This increased peak hour load increases a utility's cost of providing electricity and will likely result in the need to upgrade generation capacity and distribution infrastructure. For this analysis, it is assumed that Colorado utilities will incur a cost of $77 for each kW of increased capacity in 2030, rising to $105/kW in 2050. For transmission and distribution upgrades, this analysis assumes that Colorado utilities will incur a cost of $33 for each kW that flows over their distribution infrastructure, rising to $45/kW in 2050. See **Figure 47** for the projected utility revenue and costs from ZEV charging under the different scenarios.

Figure 47 Projected Utility Revenue and Costs from PEV Charging (2020$)



In **Figure 47**, projected utility revenue is shown in dark blue. The different elements of incremental cost that utilities would incur to purchase and deliver additional electricity to support electric vehicle charging are shown in orange (generation and transmission) and gray (incremental peak capacity). Generation and transmission costs are proportional to the total power (Megawatt-hour – MWh) used for ZEV charging, while peak capacity costs are proportional to the incremental peak load (Megawatt – MW) imposed by ZEV charging. Transmission and distribution upgrade costs are costs incurred by the utility to upgrade their own distribution infrastructure to handle the increased peak load imposed by ZEV charging.

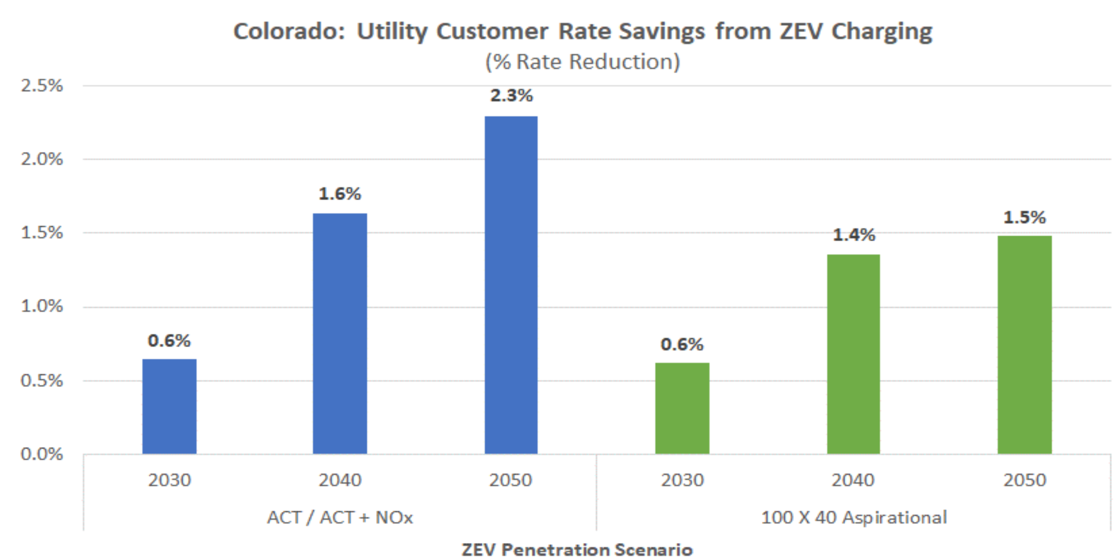
The striped light blue bars in **Figure 47** represent the projected "net revenue" (revenue minus costs) that utilities would realize from selling additional electricity for M/HD vehicle charging under each scenario.

Under the ACT and ACT + NOx scenarios, revenue from ZEV charging outweighs the costs of generating and distributing the electricity, resulting in net revenue to Colorado utilities. Net Revenue in Colorado is projected to total $23 million in 2030, rising to $95 million in 2050. For the 100 X 40 Aspirational scenario, net revenue is projected to total $22 million in 2030 rising to $61 million by 2050.

In general, a utility's costs to maintain their distribution infrastructure increases each year with inflation, and these costs are passed on to utility customers in accordance with rules established by the PUC, via periodic increases in residential and commercial electric rates. **However, projected utility net revenue from increased electricity sales for ZEV charging could put downward pressure on rates to customers**.

Figure 48 presents a summary of how the projected utility net revenue from ZEV charging might affect average residential and commercial electricity bills for all Colorado electric utility customers. Under the ACT and ACT + NOx scenarios, projected average electric rates in Colorado could be reduced up to 2.3 percent by 2050, resulting in an annual savings of approximately $70 (nominal dollars) per utility customer in Colorado in 2050.[xliii]

Figure 48 Utility Customer Rate Savings from ZEV Charging (% Rate Reduction)



[xliii] Based on an assumed 20,000 kWh of annual usage

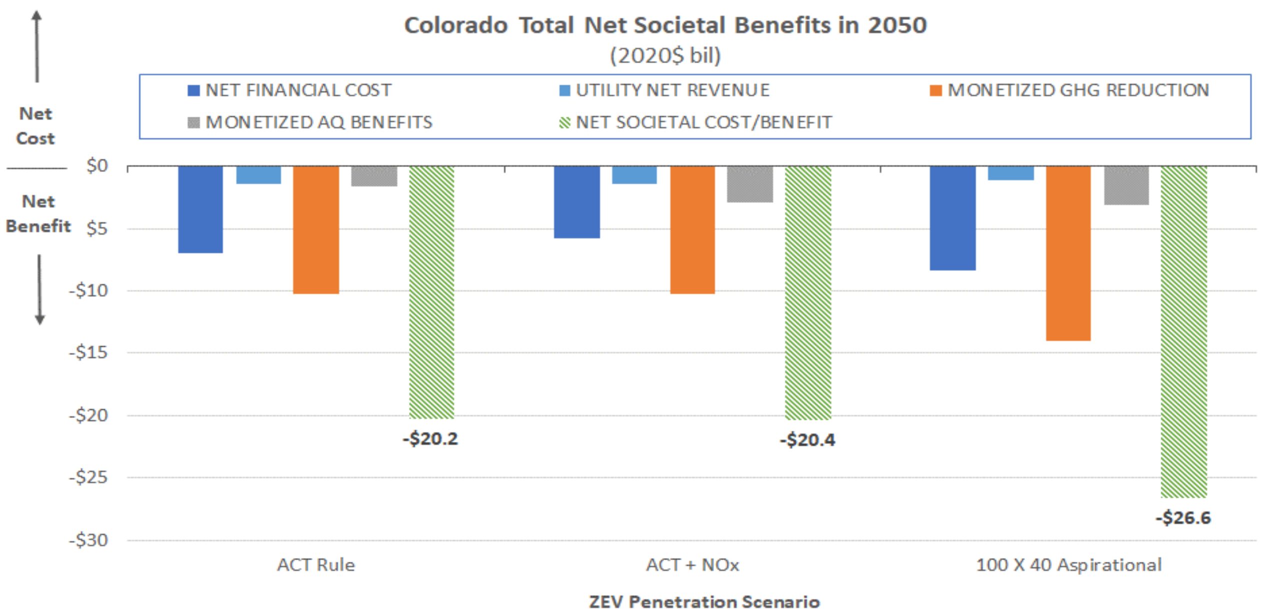
Total Societal Costs/Benefits

The total estimated societal costs from increased M/HD ZEV use in Colorado under each scenario are summarized in **Figure 49**. This chart shows the cost savings to Colorado ZEV owners, utility customer savings from reduced electric bills and the monetized benefit of reduced GHG, NOx and PM emissions.

In Figure 49, the blue bars represent the net financial costs, the negative light blue bars correspond to utility revenue from vehicle charging, the negative orange bars represent the monetized GHG benefits from ZEV vehicle penetration, while the negative gray bars reflect the monetized air quality benefits of ZEV and low NOx vehicles. The green striped bars represent the net societal cost (or benefit) for each of the scenarios (net financial costs minus benefits).

All scenarios are projected to result in a net societal benefit ranging from $20.2 billion to $26.6 billion (2020$), depending on the scenario. These net benefits are due to the net financial savings to Colorado ZEV owners (**Table 11**), sizeable GHG monetized savings and air quality benefits (**Figure 31)** along with utility net revenue from increased M/HD electrification (**Figure 47**).

Figure 49 Total Net Societal Benefits in 2050 (2020$ Billion)



Conclusion

As demonstrated throughout this report, Colorado can leverage a host of strategies to reduce air pollution and make progress towards the GHG emission reduction goals of 26 percent by 2025, 50 percent by 2030, and 90 percent by 2050. This analysis finds that if the state of Colorado pursues strategies that support an accelerated transition to M/HD ZEV— a component of the state's larger goal of achieving a 100 percent ZEV transportation sector by 2050—it could reduce the state's M/HD GHGs 45 to 59 percent, NOx emissions 54 to 93 percent, and PM emissions 53 to 68 percent annually by 2050 from the baseline. Not only will this have a meaningful impact on the state's contribution to climate change but it will also have a significant impact on communities across Colorado that suffer from poor air quality due to elevated levels of transportation related air pollutants and—as the analysis displays— will have meaningful net societal, revenue, and costs savings for Coloradans (outlined below).

- **All scenarios will result in a net societal benefit ranging from $20.2 billion to $26.6 billion (2020$)**. These benefits are due to the net financial savings to Colorado ZEV owners, sizeable GHG monetized savings and air quality benefits along with utility net revenue from increased M/HD electrification, in addition to significant savings from better health due to cleaner air.
- **Utility Net Revenue from electrification in Colorado is projected to total $23 million in 2030, rising to $95 million in 2050 under the ACT and ACT + NOx scenarios.** For the 100 X 40 Aspirational scenario, net revenue is projected to total $22 million in 2030 rising to $61 million by 2050.[xliv]
- **M/HD ZEVs after 2040 are projected to save their owners an average of $22,678 under the ACT and ACT + NOx scenarios. These savings increase to $24,193 per vehicle under the 100 X 40 Aspirational scenario.** Although the initial costs for ZEVs are greater than conventional gasoline and diesel vehicles, the lower fuel and maintenance costs outweigh the initial incremental costs resulting in net financial savings. These savings will be in the form of reduced fuel and maintenance costs to Colorado vehicle owners.
- **ZEVs offer significant fuel cost and maintenance savings.** Fuel savings per ZEV on an annual basis for the ACT and ACT + NOx scenarios are estimated to provide nearly $850 per ZEV per year, while the 100 X 40 Aspirational increases this savings to more than $1,200 per ZEV per year by 2050. Similar for maintenance savings, ZEVs will help save vehicle owners money by reducing the maintenance costs annually, ranging from $807 per ZEV to $1,111 per ZEV per year. In the interim time periods of 2021-2030 and 2031-2040, combined fuel and maintenance savings are estimated at $2,100 and $2,500 per year, respectively.

As the Colorado Energy Office begins to develop a detailed plan for M/HD ZEV deployment, it will be critical for the state to work with a wide variety of stakeholders to determine a suite of policies that will lead to meaningful emissions reductions. The Colorado Energy Office should consider the following actions and key takeaways when developing a more detailed M/HD ZEV Action Plan for the State of Colorado.

Evaluate and adopt a suite of policies that will drive adoption: To create substantial change at the scale needed to reach high levels of ZEV penetration in the M/HD sector, Colorado must bolster existing programs and implement a wide variety of additional policies and programs that address different types of barriers to

[xliv] Utility net revenue is considered a societal benefit because, assuming nearly all residents of the state have access to electricity, the opportunity for increased revenue is anticipated to lead to lower electric rates – a benefit to all that purchase electricity.

M/HD ZEV deployment—many of these policy approaches have been discussed throughout this report. This will require a coordinated effort from policymakers, state agencies, fleets, and Colorado's communities.

Center coordination and policy implementation around stakeholder voices and perspectives: The state of Colorado has a significant role to play in convening stakeholders throughout the M/HD vehicle value chain. Major stakeholders will include fleets operating within the state, utilities, OEMs, environmental justice and disadvantaged communities, fuel suppliers, infrastructure developers and community colleges, among others. Collaboration with fleets should build upon existing networks and collaborations like the Colorado Freight Advisory Council and Electric Vehicle Coalition and open new channels that engage fleets, particularly smaller fleets that may not have the capacity for rapid ZEV conversion. Environmental justice and disadvantaged communities'—including Colorado's rural populations—voices and experiences should be considered during both policy development and allocation of revenue, as these communities are often disproportionately affected by transportation emissions. Achieving this ambitious goal will require leveraging a wide range of policy levers and support from a diverse set of stakeholders, including both public and private entities. State entities have a key role to play in reducing the risk and uncertainty in the M/HD ZEV market—for fleet operators as well as other key stakeholders throughout the M/HD vehicle value chain.

Colorado's state and local governments could make a significant contribution to the state's M/HD ZEV goals by leading by example. State, county, and city governments, including transit authorities and school districts, own about half of the vehicles in the 100 largest fleets in Colorado. Combined, these segments represent a substantial procurement opportunity within the state.

There are significant near-term opportunities to incentivize and promote the adoption of M/HD ZEVs in Class 3, electric bus, and school bus fleets within the state: Colorado has a significant number of Class 2b and Class 3 trucks registered in the state. Many of these vehicles are older, meeting less stringent emissions regulations and contributing to NOx and PM emissions in the local areas. Adopting regulations such as the ACT or scrappage programs could help to alleviate their impact and increase potential ZEV sales within the state. Significant development in zero emission Class 3 vehicles is ongoing and market availability is expected to grow rapidly in the near future.

There is an established market for transit and school bus ZEVs making their procurement and deployment easier in the short term. With the right combination of regulations and incentives, both transit and school buses could follow – or exceed – their current growth trajectories.

Vehicle turnover rates, procurement cycles, and ownership models are all interrelated and important considerations for ZEV deployment as they affect —all else equal— how quickly the average vehicle will be replaced: In many cases, the average vehicle's life is more than 30 years – meaning that for states that are prioritizing increased M/HD ZEV deployment in the near term, market interventions, including financial incentives, ZEV procurement requirements, as well as infrastructure development will need to be implemented to speed up the ZEV deployment process.

Vehicle usage patterns will impact how readily a M/HD vehicle operator/owner is able to transition to ZEVs: Spanning the M/HD sector is a diverse group of vehicles ranging from city delivery vehicles and conventional vans to cement and long-haul trucks. Within these differing vehicle classes, exists a variety of vehicle vocations which have varying operating characteristics. These differences will vary widely from having a minimal impact on the functionality of a vehicle (i.e., a truck that is used for general operations will have different vehicle requirements when compared to a similarly sized truck that is used to plow snow during the winter) to having a significant impact on a fleets ability to transition to ZEVs (i.e., a long-haul truck and a regionally operated delivery van will face wildly different barriers to transitioning to ZEVs based upon their vehicle usage patterns and access to fueling infrastructure).

Harness and streamline existing relationships to increase ZEV workforce training opportunities within the state: Many community colleges within the state have successful, long-standing relationships with OEMs but could benefit from an entity that is able to convene multi-stakeholder workgroups or task forces that could organize a coordinated approach to developing ZEV training programs across the state. The state could serve as an organizing body for convening stakeholders in developing a ZEV curriculum in a coordinated rather than siloed approach.

Incentivize Class 2b Vehicles: Class 2b vehicles are by far the largest population of registered M/HD vehicles in Colorado and it is surmised that a very large portion of the Class 2b vehicles are either personal vehicles or are owned by very small (less than 5 vehicles) commercial fleets within the state. Transitioning these to ZEV will require focus on commercial and personal truck owners and, for example, if incentives are

Appendices

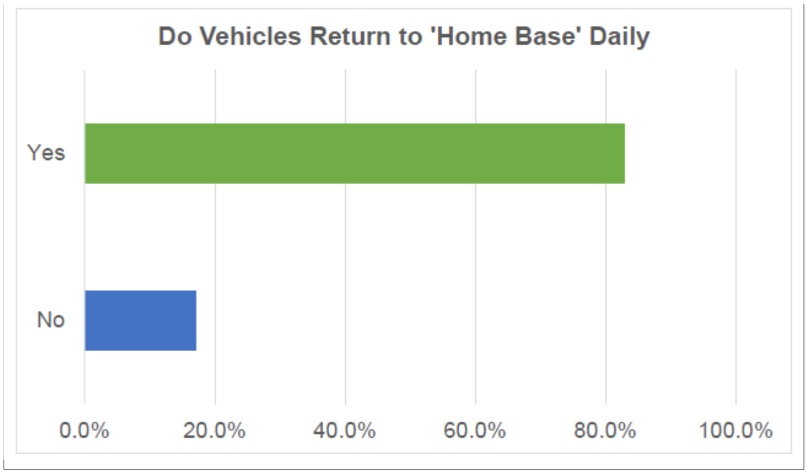
Appendix I —Survey Responses

An iterative process occurred using the ideal information list that was included in the scope of work and feedback from Colorado transportation stakeholders (e.g., CMCA) to develop an online survey that attempted to strike a balance between gathering useful information and not being so cumbersome such that fleets would not take the time to respond. As a result, the survey went live with a targeted set of questions from which we can surmise fleet attitudes towards ZEVs as well as gain insight into purchasing patterns, likelihood of vehicles to return to a 'home base' daily and what kind of mileage accumulation occurs.

Approximately 80 responses were logged, although some data (e.g., mileage) was incomplete. Of these ~80 responses, 8 of the top 100 fleets in Colorado (by number of registered vehicles) responded. The survey allowed users to remain anonymous, although a number of fleets did express willingness for follow-up conversations by providing contact information.

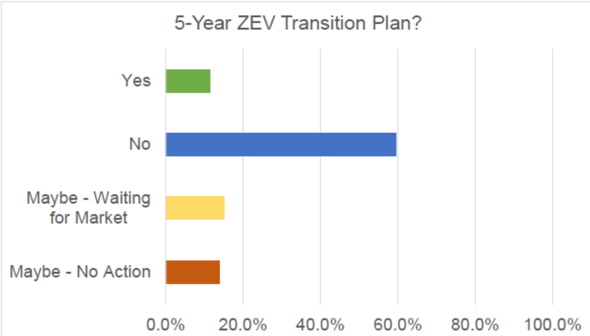
Different fleet types and owners responded with trucking, transit buses, school buses, and motor coaches included. Because of the anonymous nature of the survey, MJB&A was not able to identify which fleets/types responded but did have responses from at least one each of municipal fleets (trucks & transit), private bus operators, heavy equipment operators, agricultural companies (e.g., farms), towing company, road construction, refuse haulers, freight hauling, and local delivery.

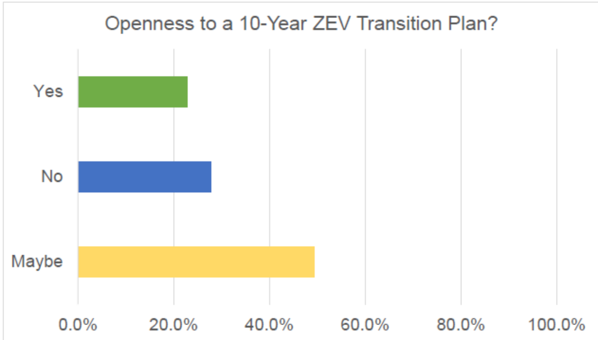
Figure 1A Survey Results Fleet Operating Pattern



By looking at survey responses, we are able to preliminarily posit that most vehicles return to a 'home base' daily, which is an important data point when considering the electrification (vs. hydrogen or RNG) ZEV pathway. Additionally, there appears to be some openness among Colorado M/HD fleets for considering ZEV technology (potentially in the absence of any standard), but that a number of fleets are withholding judgement/action until the marketplace more fully evolves with vehicles to purchase. It is important to note; however, that the survey sample size is very small compared to the number of fleets and M/HD vehicles in Colorado, so reliance on any conclusions from the survey should be tempered.

Figure 2A Survey Results – 5- and 10-Year Transition Plans





Appendix II – Fleet Consumer Purchase and Manufacturer Model Announcements as of April 2021 – Medium- and Heavy-Duty Vehicles

This table includes only models with an announced model name and model year introduction date. Other data is included if available; blank cells indicate that the data is not available from the manufacturer. **Table 1A** lists notable fleet ZEV procurement announcements while **Table 2A** lists longer-term goals and timelines fleets have announced to reach high ZEV penetration. This Appendix also includes a list of current M/HD models announced to date. [xlv]

Table 1A Sample Fleet Procurement Announcements

Sector[i]	Fleet	Manufacturer	Quantity
Power	SoCalGas	Landi Renzo USA	200 RNG Ford F-250 service pickup trucks
Delivery	Amazon	Rivian	100,00 electric delivery vans
	FedEx	BrightDrop	500 electric delivery vans
	UPS	Workhorse	950 electric trucks
	UPS	Arrival	10,000
	DHL	Workhorse	63 electric delivery vans
Food and Beverage	Anheuser-Busch	BYD	21 electric trucks in California
	Anheuser-Busch	Nikola	800 hydrogen-electric powered semi-trucks
	PepsiCo.	Tesla	100 electric semi-trucks
	Sysco Corporation	Tesla	50 electric semi-trucks
Municipal	Los Angeles Department of Transportation	BYD and Proterra	130 transit buses from BYD and 25 from Proterra *BYD purchase is the largest single purchase of electric buses in the U.S. to date*

[xlv] Announcements are current as of early Spring 2021 except this reflects a June update regarding the Tesla Semi.

Table 2A Sample Fleet Targets

Sector[131]	Company	Electric Fleet Targets
Retail	Ikea Group	2020: Electrify deliveries in Amsterdam, Los Angeles, New York, Paris, and Shanghai (25 percent global of deliveries) 2025: 100 percent EV or other zero-emissions solutions for deliveries and services through suppliers
	Amazon	2022: 10,000 electric delivery vans (short-term goal) 2030: 100,000 electric delivery vans total (long-term goal)
	Clif Bar & Company	2030: 100 percent fleet electrification
	Unilever	2030: 100 percent fleet electrification (11,000 vehicles)
	Walmart	2040: Zero emission vehicle fleet, including long-haul (6,000 trucks)
Power	Edison Electric Institute (EEI) Member Companies (investor-owned utilities)	2030: More than 70 percent of EEI member companies will collectively electrify more than one-third of their total fleet vehicles, including two-thirds of passenger vehicles in fleets. Examples include: • Xcel Energy: 2023: 100 percent electric sedan portion of fleet; 2030: 100 percent electric light-duty fleet; 30 percent M/HD vehicles • Consumers Energy: 2025: Buy or lease 100 percent of EVs for fleet • Southern California Edison: 2030: 100 percent electric passenger car and small-to mid-size SUV, 30 percent medium-duty vehicles and pickup trucks, 8 percent heavy-duty trucks, 60 percent forklifts
	Schneider Electric	2030: 100 percent electric fleet (14,000 vehicles)
Transit	Antelope Valley Transit (CA)	2018: Convert all the agency's aging diesel buses to a 100 percent battery electric bus fleet with up to 85 new all-electric buses
	King County Metro (WA)	2030: 100 percent zero-emissions fleet
	Lime	2030: 100 percent conversion of operations fleet
Delivery	DHL	2025: 70 percent of first- and last-mile delivery services with clean transport modes 2050: Reduce logistics-related emissions to zero
	FedEx	2025: 50 percent of Express global parcel pickup and delivery (PUD) fleet purchases electric 2030: 100 percent PUD fleet purchases electric 2040: 100 percent ZEV PUD fleet
Food and Beverage	Anheuser-Busch	*Unspecified Date:* 30 percent of fleet to RNG vehicle (180 vehicles)
Biotech	Genentech	2025: 100 percent electrification of commuter buses (60 buses)
Municipal	New Jersey	2024: At least 10 percent of new bus purchases will be zero emission buses 2026: At least 50 percent of new bus purchases will be zero emissions buses 2032: 100 percent of new bus purchases will be zero emissions buses
	Los Angeles, California	2028/2035: 100 percent ZEV vehicle conversions "where technically feasible" (2028: taxi fleet, school buses; 2035: urban delivery vehicles) 2035: 100 percent electrification of sanitation fleet through LA Department of Sanitation Commitment
	Montgomery County, Maryland	2033 (approximately 12-year process): Electrify entire school bus fleet for Montgomery County Public School district (1,400 school buses serving over 200 schools)
	New York City, New York	2035: 100 percent electric school bus fleet (960 buses) 2040: 100 percent electric Metropolitan Transit Authority (MTA) bus fleet
	Chicago, Illinois	2040: 100 percent electric Chicago Transit Authority (CTA) bus fleet (1,850 buses)

Table 3A Medium-Duty Vehicle Manufacturer Announcements

Manufacturer	Model	Weight Class	Availability	Battery (kWh)	Range (mi)
Electric Last Mile Services	Elms EV Urban Delivery Van	Class 1	2021		150
Arrival	The Arrival Van	Class 2b-3	2022	44-133	112-211
Atlis Motor Vehicles	XP Platform (Chassis)	Class 2b-3	2022		
Bollinger	B2 Chass-e Cab	Class 2b-3	2022	105, 140	200
Bollinger	Chass-E (Chassis)	Class 2b-3	2022	105, 140	200
CityFreighter	CF1	Class 2b-3	2022		
EVT Motors	Urban Truck	Class 2b-3	2021	92.5	173
EVT Motors	Van	Class 2b-3	2021	106.2	109-173
Ford	E-Transit	Class 2b-3	2021	43-86	60-126
General Motors (BrightDrop)	EV600	Class 2b-3	2021		250
Lightning eMotors	Transit Cargo Van	Class 2b-3	2021	86, 105	140, 170
Rivian	Cargo Van	Class 2b-3	2021 (Amazon Only)		
SEA Electric	Ford Transit EV	Class 2b-3	2021	88	190
Workhorse	C 650	Class 2b-3	2021	35, 70	100, 160
Workhorse	C 1000	Class 2b-3	2021	35, 70	100, 160
Canoo	MPDV2	Class 4	2022		
Dana Nordesa	W4	Class 4	2021	80, 160	75, 150
Dana Nordesa	T4	Class 4	2021	80, 160	75, 150
Greenpower	EV Star Cargo+	Class 4	2021	118	150
Greenpower	EV Star Cargo	Class 4	2021	118	150
Greenpower	EV Star CC	Class 4	2021	118	150
Lightning eMotors	E-450 Cutaway	Class 4	2021	86, 129	80,120
Motiv	Epic E450	Class 4	2021	127	105
Phoenix Motors	Zeus 500	Class 4	2021	70-150	80, 115, 150
SEA Electric	Isuzu NPR	Class 4	2021	100	170
BYD	6F	Class 5-6	2021	221	125
BYD	6R	Class 5-6	2021		85
BYD	6D	Class 5-6	2021	221	120
Chanje	V8100	Class 5-6	2021	100	150
Daimler	Freightliner MT50e (Chassis)	Class 5-6	2021	226	125
Dana Nordesa	T5	Class 5-6	2021	80, 160	60, 120
Dana Nordesa	T6	Class 5-6	2021	160	120
EVT Motors	Electric Van Cuttaway	Class 5-6	2021	106	173
Kenworth	K270E	Class 5-6	2021	141	100, 200
Lightning eMotors	F-59 Cargo Van and Food Truck	Class 5-6	2021	128, 160, 192	110, 140, 170

Manufacturer	Model	Weight Class	Availability	Battery (kWh)	Range (mi)
Lightning eMotors	6500XD Cab Forward Truck	Class 5-6	2021	122, 153, 184	88, 110, 130
Lion Electric	Lion6	Class 5-6	2021	252	180
Motiv	Epic F-59	Class 5-6	2021	127	105
Navistar	International Trucks eMV	Class 5-6	2021	321	250
Peterbilt	220EV	Class 5-6	2021	140-348	200
Rousch CleanTech	Ford F-650	Class 5-6	2021	138	100
SEA Electric	Ford F-59	Class 5-6	2021	138	200
SEA Electric	Ford F-650	Class 5-6	2021	138	200
SEA Electric	Hino 195	Class 5-6	2021	138	200
SEA Electric	Isuzu NRR	Class 5-6	2021	138	200
SEA Electric	Isuzu NQR	Class 5-6	2021	138	200
XOS	X-Platform (Chassis)	Class 5-6	2021		200
Zenith Motors	Electric Step-Van	Class 5-6	2021		90
Hino	L6 and L7	Class 6-7 Tractor	2021		

Table 4A Heavy-Duty Vehicle Manufacturer Announcements

Manufacturer	Model	Weight Class	Availability	Battery (kWh)	Range (mi)
BYD	8R	Class 7-8 Rigid	2021		75
Daimler	Freightliner eM2	Class 7-8 Rigid	2021	325	230
Dennis Eagle	eCollect	Class 7-8 Rigid	2021	300	
Enride	Pod	Class 7-8 Rigid	2022/2023		112
Kenworth	K370E	Class 7-8 Rigid	2021	282	100, 200
Lion Electric	Lion8 Tandem	Class 7-8 Rigid	2021	336	170
Lion Electric	Lion8 Refuse	Class 7-8 Rigid	2021	336	130
Lion Electric	Lion8 Bucket	Class 7-8 Rigid	2021	336	
Nikola	Refuse	Class 7-8 Rigid	2023		150
Peterbilt	520EV (Refuse)	Class 7-8 Rigid	2021	308-420	60-90
SEA Electric	Ford F-750	Class 7-8 Rigid	2021	138	170
SEA Electric	Isuzu FTR	Class 7-8 Rigid	2021	138	200
SEA Electric	Refuse	Class 7-8 Rigid	2021	138, 220	
Volvo	VNR Electric Straight Truck	Class 7-8 Rigid	2021	264	150
Volvo Group	Mack Trucks LR Electric	Class 7-8 Rigid	2021		
BYD	8TT	Class 7-8 Tractor	2021	409	175
Daimler	Freightliner eCascadia	Class 7-8 Tractor	2022	550	250
Hino	XL Series	Class 7-8 Tractor	2022		
Kenworth	T680E	Class 7-8 Tractor	2021		150
Lion Electric	Lion8 Tractor	Class 7-8 Tractor	2021	588	210
Nikola	Tre	Class 7-8 Tractor	2021	750	250-300
Peterbilt	579EV	Class 7-8 Tractor	2021	264-420	110-200
Tesla	Semi	Class 7-8 Tractor	2022		300 or 500
Volvo	VNR Electric	Class 7-8 Tractor	2021	264	120
BYD	8Y	Terminal Tractor	2021		
Kalmer	Ottawa T2E Electric Terminal Tractor	Terminal Tractor	2021		

Manufacturer	Model	Weight Class	Availability	Battery (kWh)	Range (mi)
Lonestar	Lonestar SV Reman Electric Terminal Tractor	Terminal Tractor	2021		
Orange EV	T-Series	Terminal Tractor	2021		
Terberg Tractors	YT202-EV	Terminal Tractor	2021		

Table 5A Bus Manufacturer Announcements

Manufacturer	Model	Category	Availability	Battery (kWh)	Range (mi)
BYD	Coach Bus C6M - 23'/C8M - 35'/ C9M - 40'/C10M - 45'	Coach	2021	121, 313, 352, 446	124, 200, 230
Motor Coach Industries (NFI Group)	J4500e CHARGE	Coach	2021		230
Motor Coach Industries (NFI Group)	D45 CRTE LE CHARGE	Coach	2021	389, 544	170, 230
Van Hool	CX45E	Coach	2021	648	310
Blue Bird	All American RE Electric	School	2021	160	120
Blue Bird	Micro Bird G5 Electric	School	2021	88	100
Blue Bird	Vision Electric	School	2021	160	120
Daimler	The Saf-T-Liner® eC2 Jouley	School	2021	220	135
Greenpower	The BEAST	School	2021	193.5	150
Lion Electric	LionA	School	2021	80, 160	75, 150
Lion Electric	LionC	School	2021	210	100, 125, 155
Lion Electric	LionD	School	2021	210	100, 125, 155
Motiv	Epic F59	School	2021	127	105
Navistar	IC Bus CE Series Electric	School	2021	105-315	70-200
Phoenix Motors	Zeus 600 School Bus	School	2021	70, 105, 140	80, 115, 150
Greenpower	EV Star	Shuttle	2021	118	150
Greenpower	EV Star+	Shuttle	2021	118	150
Greenpower	AV Star	Shuttle	2021	118	150
Lightning eMotors	Transit Passenger Van	Shuttle	2021	86, 105	140, 170
Lightning eMotors	E-450 Shuttle	Shuttle	2021	86, 129	80, 120
Lightning eMotors	F-550	Shuttle	2021	122	100
Lion Electric	LionM	Shuttle	2021	160	75, 150
Motiv	Epic E450	Shuttle	2021	127	105
Optimal EV	S1LF	Shuttle	2021		200
Phoenix Motors	Zeus 400 Shuttle Bus	Shuttle	2021	70, 105, 140	80, 115, 150
SEA Electric	E4B Commuter Bus	Shuttle	2021	88	186
Zenith Motors	Electric Shuttle	Shuttle	2021		90,110
Arrival	The Arrival Bus	Transit	2023		
BYD	Transit Bus K7 - 30'/K9 -S 35'/ K9 - 40'/K11 - 60'	Transit	2021	215, 266, 352, 446	137, 145/215, 156, 220

Manufacturer	Model	Category	Availability	Battery (kWh)	Range (mi)
BYD	Double Decker C8MS - 35' / C8MS - 45'	Transit	2021	113, 446	170, 230
Gillig	Battery Electric Bus (40')	Transit	2021	148-444	150, 210
Greenpower	EV 250 (30')	Transit	2021	210	175
Greenpower	EV 350 (40')	Transit	2021	430	200
Greenpower	EV 550 (45' Double Decker)	Transit	2021	478	175
Hyundai	Battery Elec City	Transit	2021	256	130
Lightning eMotors	Electric Zero Emission City Transit Bus Repower	Transit	2021	320	140, 200
New Flyer	Xcelsior CHARGE 35', 40', and 60'	Transit	2021	350, 440, 525	179, 220 / 174, 213, 251 / 153
New Flyer	Xcelsior AV	Transit	2021	Can integrate Xcelsior CHARGE platform	
Proterra	ZX5 40' and 60'	Transit	2021	450, 675	240, 329
Volvo Group	Nova Bus LFSe/LFSe+	Transit	2021	564	75, 292
BYD	Coach Bus C6M - 23'/C8M - 35'/ C9M - 40'/C10M - 45'	Coach	2021	121, 313, 352, 446	124, 200, 230
Motor Coach Industries (NFI Group)	J4500e CHARGE	Coach	2021		230

Source: MJB&A EV Market Status Report with support from the Environmental Defense Fund

Appendix III – Net Financial Results for All Modeling Scenarios

Table 6A Scenario A —ACT Rule

			2021 - 2030	2031 - 2040	2041-2050	TOTAL
Incr ZEV Purchase		2020$ mill	$341	$548	$279	$1,168
		nom$ mill	*$392*	*$751*	*$476*	*$1,619*
Incr Low-NOx ICE Purchase		2020$ mill	$0	$0	$0	$0
		nom$ mill	*$0*	*$0*	*$0*	*$0*
Charging Infrastructure	**Purchase**	2020$ mill	$103	$588	$712	$1,403
		nom$ mill	*$120*	*$823*	*$1,240*	*$2,183*
	Install	2020$ mill	$47	$290	$366	$702
		nom$ mill	*$55*	*$406*	*$638*	*$1,098*
Petroleum Fuels		2020$ mill	($445)	($4,622)	($10,587)	($15,655)
Electricity		2020$ mill	$367	$3,121	$6,470	$9,958
Hydrogen		2020$ mill	$0	$0	$0	$0
NET FUEL COST		2020$ mill	($79)	($1,501)	($4,117)	($5,697)
		nom$ mill	*($94)*	*($2,140)*	*($7,222)*	*($9,456)*
Incr Veh Maintenance		2020$ mill	($87)	($1,477)	($3,935)	($5,500)
		nom$ mill	*($103)*	*($2,107)*	*($6,906)*	*($9,116)*
Charger Operations & Maintenance		2020$ mill	$26	$277	$651	$954
		nom$ mill	*$31*	*$393*	*$1,142*	*$1,566*
NET FINANCIAL COST		2020$ mill	**$350**	**($1,275)**	**($6,044)**	**($6,969)**
		nom$ mill	***$400***	***($1,874)***	***($10,632)***	***($12,107)***

Incr ZEV Purchases	mill	*0.03*	*0.22*	*0.28*	*0.54*
AVG Incr In-use ZEV	mill	*0.01*	*0.14*	*0.37*	*0.227*
AVG Incr Purchase Cost	2020 $/ZEV	$9,933	$2,502	$988	$2,178
AVG Charging Infra Cost	2020 $/ZEV	$4,348	$4,007	$3,812	$3,926
AVG Annual Fuel Cost Sav	2020 $/ZEV	($1,000)	($1,071)	($1,124)	($836)
AVG Annual Maint Cost Sav	2020 $/ZEV	($1,113)	($1,054)	($1,074)	($807)

Table 7A Scenario B —ACT Rule + Heavy-Duty Low NOx Omnibus

			2021 - 2030	2031 - 2040	2041-2050	TOTAL
Incr ZEV Purchase		2020$ mill	$341	$548	$279	$1,168
		nom$ mill	*$392*	*$751*	*$476*	*$1,619*
Incr Low-NOx ICE Purchase		2020$ mill	$382	$464	$368	$1,213
		nom$ mill	*$436*	*$632*	*$639*	*$1,708*
Charging Infrastructure	**Purchase**	2020$ mill	$103	$588	$712	$1,403
		nom$ mill	*$120*	*$823*	*$1,240*	*$2,183*
	Install	2020$ mill	$47	$290	$366	$702
		nom$ mill	*$55*	*$406*	*$638*	*$1,098*
Petroleum Fuels		2020$ mill	($445)	($4,622)	($10,587)	($15,655)
Electricity		2020$ mill	$367	$3,121	$6,470	$9,958
Hydrogen		2020$ mill	$0	$0	$0	$0
NET FUEL COST		2020$ mill	($79)	($1,501)	($4,117)	($5,697)
		nom$ mill	*($94)*	*($2,140)*	*($7,222)*	*($9,456)*
Incr Veh Maintenance		2020$ mill	($87)	($1,477)	($3,935)	($5,499)
		nom$ mill	*($103)*	*($2,106)*	*($6,905)*	*($9,115)*
Charger Operations & Maintenance		2020$ mill	$26	$277	$651	$954
		nom$ mill	*$31*	*$393*	*$1,142*	*$1,566*
NET FINANCIAL COST		2020$ mill	**$732**	**($812)**	**($5,676)**	**($5,756)**
		nom$ mill	***$836***	***($1,242)***	***($9,992)***	***($10,398)***
Incr ZEV Purchases		mill	*0.03*	*0.22*	*0.28*	*0.54*
AVG Incr In-use ZEV		mill	*0.01*	*0.14*	*0.37*	*0.23*
AVG Incr Purchase Cost		2020 $/ZEV	$9,933	$2,502	$988	$2,178
AVG Charging Infra Cost		2020 $/ZEV	$4,348	$4,007	$3,812	$3,926
AVG Annual Fuel Cost Sav		2020 $/ZEV	($1,000)	($1,071)	($1,124)	($836)
AVG Annual Maint Cost Sav		2020 $/ZEV	($1,110)	($1,053)	($1,074)	($807)

Table 8A Scenario C —100 X 40 Aspirational

			2021 - 2030	2031 - 2040	2041-2050	TOTAL
Incr ZEV Purchase		2020$ mill	$945	$802	$396	$2,142
		nom$ mill	*$1,075*	*$1,095*	*$673*	*$2,843*
Incr Low-NOx ICE Purchase		2020$ mill	$320	$308	$61	$689
		nom$ mill	*$365*	*$412*	*$106*	*$883*
Charging Infrastructure	**Purchase**	2020$ mill	$237	$861	$1,218	$2,315
		nom$ mill	*$274*	*$1,207*	*$2,121*	*$3,602*
	Install	2020$ mill	$108	$430	$636	$1,174
		nom$ mill	*$125*	*$604*	*$1,107*	*$1,837*
Petroleum Fuels		2020$ mill	($655)	($5,855)	($14,251)	($20,761)
Electricity		2020$ mill	$486	$3,620	$7,282	$11,387
Hydrogen		2020$ mill	$0	$173	$913	$1,086
NET FUEL COST		2020$ mill	($169)	($2,063)	($6,055)	($8,287)
		nom$ mill	*($201)*	*($2,937)*	*($10,643)*	*($13,780)*
Incr Veh Maintenance		2020$ mill	($188)	($2,018)	($5,362)	($7,568)
		nom$ mill	*($221)*	*($2,870)*	*($9,418)*	*($12,509)*
Charger Operations & Maintenance		2020$ mill	$41	$347	$801	$1,189
		nom$ mill	*$48*	*$492*	*$1,405*	*$1,945*
NET FINANCIAL COST		2020$ mill	**$1,294**	**($1,333)**	**($8,306)**	**($8,345)**
		nom$ mill	***$1,466***	***($1,997)***	***($14,649)***	***($15,180)***
Incr ZEV Purchases		mill	*0.06*	*0.28*	*0.42*	*0.76*
AVG Incr In-use ZEV		mill	*0.02*	*0.19*	*0.50*	*0.227*
AVG Incr Purchase Cost		2020 $/ZEV	$14,658	$2,881	$937	$2,800
AVG Charging Infra Cost		2020 $/ZEV	$5,348	$4,639	$4,391	$4,562
AVG Annual Fuel Cost Sav		2020 $/ZEV	($1,006)	($1,088)	($1,221)	($1,216)
AVG Annual Maint Cost Sav		2020 $/ZEV	($1,116)	($1,065)	($1,081)	($1,111)

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